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## CHAPTERS FOR A BIOLOGICAL-EMPIRICAL PSYCHOLOGY

*Nihil in Mente nisi prius in Mundo*

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### INTRODUCTION

Rectification of frontier between science and philosophy; Penultimate and Ultimate Philosophies, respective aims and subject-matter. Penultimate "explanations" merely re-statements in successively simpler terms; their advantage, progressive shifting of difficulties where they belong (to Ultimate Philosophy). Biological and psychological, wrongly identified with philosophical problem. Biological psychology and existing systems; its predominantly genetic character, utilization of introspection, exactitude, empiricism; it subsums under Penultimate Philosophy and conforms to Penultimate Logic. Consciousness no peculiar mystery, only one phase of the All-Mystery; its subordinate place in a penultimate philosophy of the cosmos, apparent nature and *modus operandi*, survival value. Foundation assumption of scientific psychology, a rigid correspondence of vividness of consciousness with amplitude, of quality of consciousness with length, of dynamic-inseparable wave. The psychologic problem, tracing of evolution of "mind," but the mystery not that of mind but of consciousness. Anomalous electrical conductivity of carbon. Universality of law of conservation of energy not impugned by any psychic fact.

Clear ideas on psychology are first possible after sharpest distinction between matter of *psychology* and matter of *philosophy*; more precisely, between *Penultimate*-philosophic and *Ultimate*-philosophic questions. Penultimate Philosophy is not concerned with noumenal problems, or with "spiritual" or "moral" meaning for the universe. Such questions are, or may be, legitimate for Ultimate Philosophy. Penultimate Philosophy has a different task; to rear a superstructure, our "elements" *being given*. For penultimate purposes, the ultimate nature of these last may be anything,—God, corpuscles, mental figments, energy turned other side to. In this philosophy, "substance" and "energy" denote merely quality-complexes *absolutely definite and constant* within the limits (temporal and spatial) of our experience with them; and "carbon" and "hydrogen" could as well be replaced by C and H, by algebraic symbols for unknown quantities, or by paragraphs enumerative of their known properties. Scientific (and no less common) language is thus stenographic, cryptographic,

hieroglyphic, algebraic, symbolic; everywhere expressive of sums total of sensible (and deducible) properties, nothing more. The final values of our symbols must come from Ultimate Philosophy. But for penultimate purposes, the language of substance-energy is all-sufficient, those purposes being fulfilled when problems are explained in penultimate terms, terms of "matter" and "motion." True, this "explanation" is no explanation at all, but merely restatement of fact in simpler terms, a tracing back of the chain of "continuity" up to, and reformulation of problem in terms of, some earlier link; a *resolution* as distinguished from a *solution*, as in algebra we resolve one equation into another with roots differing by any assignable quantity without getting nearer the values of the roots,—in short, it is a *penultimate* solution. But such resolutions have great advantage; they *progressively shift our difficulties where they belong*, on the *jenseits* of substance, to Ultimate Philosophy.

But it is no less true that *all* the realm of substance-energy lies on the hither side of the resurveyed scientific-philosophic (penultimate-ultimate) boundary. Some will still have "life" and "mind" beyond the jurisdiction of science, but this paper aims to show that these subjects fall within that jurisdiction, and that the biologic and psychologic have been wrongly identified with the philosophic problem.

Each makes his psychology (also his philosophy) in the loneliness of his own mind, and offers it to his fellows to try on. So is offered this attempt of a biologist weary of the stones proffered when in the psychological proletariat he cried unto the Chairs for bread, to bake on his own account. This psychology differs from existing systems in several respects. In conception, methodology, exegesis, it is predominantly biological; mental phenomena are subject-matter of a department of dynamic biology, "mind" is an evolution integration-product. The human (no less the existent avian, the existent reptilian) mind is but the latest ephemeral term in the integration series, and nothing is to be accepted as existing in it<sup>1</sup> which could not have evolved into it. Given a problem in human mind, biological psychology asks: How could such condition have come about, what must have been its tributary

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<sup>1</sup> One qualification only: If as the outcome (at the end, not at the beginning) of investigation, some irreducible residuum inexplicable on evolutionary principles, should emerge, then first would it be time to talk of a "soul." Only in this *a posteriori* (and not in any *a priori*) way, could science come in contact with this "entity," which otherwise remains an exclusively ultimate-philosophic creation, amenable solely to the canons of evidence, whatever they be, of Ultimate Philosophy.

forerunners in the pre-human, what the biological necessity<sup>1</sup> in this case and the neurological condition meeting it, and, lastly, does introspection throw light? The oil immersion of psychology, introspection, yields valuable hints (chiefly suggestive, confirmatory, cautionary), but is liable to all the fallibilities of interpretation inseparable from immersion work; whereas the low-power lens of the sciences (particularly comparative neurology and neuropathology), though less delicate, is interpretatively more certain. This psychology utilizes introspection within its radius of validity, and holds that had psychologists reached a consensus as to what does and what does not constitute matter of introspection, much argument about need for an Ego to appreciate likeness and difference, could have been spared.

Like all sciences, biological psychology conceives its subject-matter as exact, and subsuming under Penultimate Philosophy, it presupposes that philosophy, as specific characters presuppose the generic. For that philosophy, *why* is an illegitimate (being an ultimate) question; its *why* always means: How comes it that? This psychology, then, no more knows why the human is conscious, than the physicist why bodies "fall" together when not propped apart; as he accepts fall as matter of fact, this psychology accepts consciousness as datum of introspection. True, consciousness is a mystery, but no peculiar mystery; only one outcrop the more of the All-Mystery. We do not know what it is, but no more do we know what anything is. But answers essential for a penultimate philosophy of consciousness (characteristics and apparent nature, relations to other things, *modus operandi*), this psychology tries to give. The consciousness-series appears to be the psychic-inseparables<sup>2</sup> of a kinetic series finding nearest affinity in the heat series; therefore, inferentially referable to the infra-red (near Blondlot's N waves?). Like all energy, consciousness is *immanent*. Its action is neither dominant nor epiphenomenal, but reactive-dynamic and resistance-reducing. Though its omnipresence, marvels, and all-importance, form

<sup>1</sup> *Biological necessity*: That which *must* "somehow" come about if an organism is to survive; a condition *sine qua non* for survival. Showing biological necessity in any given case is entirely different from showing how (neurological condition) that necessity comes to be met.

<sup>2</sup> *Psychic-inseparable*: The "subjective aspect" ("inner face," etc.) corresponding to the various members of the kinetic series which arises through latentization of nerve energy; that which is experienced as consciousness.

*Dynamic-inseparable*: The kinetic species of which consciousness is the psychic expression.

Consciousness- (sensation-, thought-, feeling-) *di*: consciousness, dynamic-inseparable aspect of.

proud capstones in pretentious intoxication-philosophies, available evidence tends to show that for a penultimate philosophy of the cosmos, it is far less important; for, it is less than coextensive with the cosmos, with "life," with nervous energy even, and seems a derivative from the last under certain special conditions. Its office<sup>1</sup> accords with this. In evolution and individual alike, it appears not for itself, but as part of the plasticity-syndrome (plasticity-complex). The survival value of this is two-fold as anticipator of environmental happenings, and as enabler of multiple activity of one structure (through multiplicity of plastic operating mechanisms). Query whether the syndrome might have equally evolved without the conscious ingredient, is idle; *de facto*, it evolved with it (and, to judge from its *modus operandi*, as a *necessary*-incidental constituent). In the syndrome, the part inseparable from consciousness, is "profiting by experience," but a penultimate philosophy of consciousness will *not* say that such profiting is the outcome of the features in the psychic situation to which greatest significance seemingly attaches upon introspection, namely, the fore-imaging (fore-"knowing") "power" of mind. Rather will it say: The foundation assumption of scientific psychology being that every supra-liminal intensity of dynamic-inseparable has its attendant fourth-dimension absorption-spectrum (for inapt metaphor) in, and as, consciousness of a vividness in rigid correspondence with the amplitude, of a quality in equally rigid correspondence with the length, of the dynamic-inseparable wave; then, *given an awareness-consciousness at all*, along with organization of nervous connections *sine qua non* for existence (through rendering possible profiting by experience), there must have proceeded a mosaic-ing of the discrete psychic-inseparable mirror-facets into the environment-parallel awareness-patterns which make up mind. Profiting and fore-imaging are, thus, parallel concomitants (co-expressions, co-functions) of nervous organization. The psychological problem is tracing the evolution of mind. But *the* "mystery" (ultimate-philosophic question) is not that of mind but of consciousness; not why mind-mirror now images environment so perfectly, but why energy happens to have an awareness feature linked with it. But, *for psychology*, it suffices that this is datum of introspection.

Biological psychology conforms to Penultimate Logic, which, like Penultimate Philosophy, sums to acceptance of *de facto*. This logic propounds but one riddle: Is there evidence (demonstration, probability of all grades down to possibility, room

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<sup>1</sup>*Biological Office*: The net effect, rôle; what teleologists meant by "purpose."

for legitimate hypothesis) showing whether, *as matter of fact* this condition does or does not obtain? Before experience, nothing; from observation, facts; from facts, inductions, deductions, hypotheses, the last to be verified by observation, or where impossible, to be tested with regard to agreement (or at least non-conflict) with established fact or generalization,—that is Penultimate Logic (simple straightforward logic of science). In this logic, it matters not that the condition be unimaginable (“unthinkable”); that is beside the penultimate question. Everything is alike unimaginable; determine facts *as facts*,—then *credo, nec impossibile*.

This essay aims at a theory as to nature and mode of action of consciousness which shall be all-embracing, conflict with no established fact or generalization, accord with the law of the conservation of energy, conform to accepted modes of scientific reasoning, and conflict with no datum of introspection. It shows how an anomaly of carbon hitherto ignored, explains (1) why carbon compounds alone admit of that complication of molecular structure characteristic of “organic” compounds; (2) why the period antecedent to the emergence of “life” may well have been one of progressive molecular complication; (3) how, with transit of impinging energies, only carbon compounds undergo modification in such manner that resistance is less for subsequent transits than for the initial transit, which modification being the basis of the most fundamental *sine qua non* for existence, profiting by experience, in carbon compounds alone can the phenomena summing to “life” come to be manifested; and (4) how (a) in the intensification-stage of this process in nerve tissue, involving emergence of consciousness (as a critical phenomenon when the relation between nerve energy and resistance comes to exceed a certain “limen” value), the reactive resistance-reducing effect of consciousness eventuates in unlimited profiting by the individual experience, and (b) subliminal recession of the emerged consciousness takes place in connection with expenditure in intra-molecular work. With these conditions as bases, and utilizing electrical principles, attempt is made to explain the principal varieties of nervous action; conduction in the infra-liminal ad-cortical and ab-cortical areas, and especially in the labyrinthine mazes of the cortical-psychic zone. Above all else, solution of the cortical-psychic problem is sought, that the equation of the conservation of energy within the living body may be knit up. Three “mental elements” are recognized, *and defined*; and analysis forces admission of distinct molecule-types to account for non-lapse of sensations and their dependency of function upon intensity of stimulus, for lapse of thought, and for non-lapse and dependency of function upon intoxication conditions, of feelings.

And it is found that no need exists by reason of any psychic fact, for impugning the universality of the law of the conservation of energy; rather, there is every warrant for holding that equally with all physical facts, all psychic facts subsum under that law.

Despite dogmatic tone, inevitable considering the brevity, this essay is *all theory*,—just like Professor So-So's big good volumes, but here theory is labeled. No preliminary attempt like this can be the last scientific word on consciousness; ample indeed would it be should this attempt prove the first such word. But one thing is certain; if it be not such first word, that word yet remains to be spoken. *The desideratum* for psychology is *some* hypothesis which shall bring mental phenomena into a connected whole; for no science can progress in advance of formulation of its basal theory.

Had conditions admitted, blemishes inevitable with defective vision would have been avoided. But the facts appealed to are well known, and the only especially original feature is the view point; orientation of data round the electrical anomaly of carbon and dynamic-neurological conception. The rest is culture-material whose source is often forgotten, and for which I cheerfully admit indebtedness to nearly every one.

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## CHAPTER I

### BIODYNAMICS AND BIOGENESIS

Anomalous electrical behavior of carbon; explaining why carbon alone forms basis of "organic" and *a fortiori*, of "life" compounds, its compounds alone being susceptible of modification under impact of energies, in such manner that reaction to subsequent such impacts is less difficult than reaction to the initial impact ("profiting by experience," origin of "genetic" series). Presumable difference in degree of anomaly among the various carbon compounds, affording a basis for the line of increasing molecular complication leading, in absence of microorganisms to effect decomposition, to compounds capable of manifesting *n-a* of the phenomena summing to "life," to which might come to be added the remaining *a* properties. Conceivable modes of development of reproduction and motion. Lines along which, *de facto*, variations came to accumulate; the plant line and the animal line, and the dynamic characteristics of each.

Carbon exhibits an anomaly all-important for explanation of "life" phenomena, its electrical resistance *decreasing*, whereas with every other conductor<sup>1</sup> resistance *increases* upon heating. And it carries this anomaly into at least some of its compounds (wax, paraffin, gutta percha, vulcanized rubber,

<sup>1</sup> Except antimony, an exception to be supplied *wherever* "carbon compounds alone" (or equivalent phrase) appears.

ebonite). Decrease in resistance upon heating must likewise take place with gases, they conducting better when rarefied; such decrease also occurs with sulphur (a "non-conductor"), and is a feature of electrolytic conduction.

Comparing, now, behavior toward the electric current, of metallic salts, *e. g.*, zinc chloride, with that of carbon compounds, supposing elements to carry into their compounds all their properties (however masked these may be), the heat emerging upon passage of the current will entail increased resistance in the zinc, but decreased resistance in the chlorine. This assumption by the component atoms, of opposite conduction phases, accords with (and probably explains) their observed readiness to separate, in electrolysis. For, if conduction mean capacity for harmonic vibration, and if molecular integrity be contingent upon the same capacity, then such assumption will introduce vibrational discord incompatible with the continued existence of the molecule.

The case must be the same with carbon compounds such as carbonates, into which a metal enters; accordingly such molecules remain quite simple and are not classed as "organic." Quite different would seem the case of compounds of carbon with elements in which resistance decreases upon heating; here, the heat effect of the current tends to bring all component atoms alike (though probably not in equal degree) into that harmony of vibration implied in the better conduction. Consequently, in such molecules, conduction will come increasingly to supplant decomposition, any resistance tending to become eliminated through reactive effect of the entailed temperature-increase. We thus reach molecules less prone to shattering under action of impinging energies; the possibility of indefinite molecular complication and of the colloidal state.

But some carbon compounds must possess capacity for reacting to energy-impacts in the way of conduction as against decomposition, in higher degree than others; to maintain the contrary, is to assert that the other atoms contribute nothing towards the properties of the molecule. And when such a molecule enters into higher combinations, the resulting super-molecules will be, as compared with the parent-molecules, either equally capable of conduction and decomposition, less capable of conduction but more so of decomposition, or more capable of conduction and less so of decomposition.

Neither of the first two exhibits nearer approach to the vital condition, but the third possibility does; and if amid numerous compounds of this type, one emerged in which in the presence of certain energy-conditions, an atom-group should become split off, with which in the presence of other energy-conditions, the molecule-remainder could recombine, we should



already have a crude metabolism. And just such compounds are the enzymes.

These ferments, indeed, possess metabolism (capability of back-and-forth play of take-up and let-go), resembling that of "living" compounds in (1) being quantitatively unlimited as long as (2) undue accumulation of products of their action is prevented, such accumulation inhibiting further activity, with ferment and living compound alike. And the only difference of moment between the two classes of compounds is that the living possesses capacity for "growth." For, of characters considered distinctive of "life," reproduction is a derivative of growth, and motion seems a physical-chemical reaction to environment.<sup>1</sup>

But growth is merely predominance of intake over output; instead of *immediately* after assimilating a molecule, disgorging in decomposition-products its exact equivalent, the life compound disgorges products equivalent to only a portion of the intake, the remainder being held combined, for a longer time.

Motivated by the growth force, the life compounds tend to grow till some counter-force comes into play; but mass increasing as the cube, surface (digestive, respiratory) only as the square, growth must have *some* limit. The sphere representing minimal surface for given mass, larger masses can accumulate in elongate-flattened form. But this form involves frangibility leading to fracture under impact of incident forces (wave action). The fragments, however, can grow to the original size, and reproducing the original frangibility, will repeat the fracture.

Crude as such reproduction would be, its importance cannot be overestimated; for the elongate-flattened forms will thenceforth increase by geometrical progression, while non-fracturing spherical forms will increase only by accession of newly evolved molecules. But causes of decrease (food scarcity) will operate about equally, elongate-flattened forms having even here the advantage incident to greater surface. Thus, even before the advent of carnivorous metabolism, there will be a steady trend toward numerical predominance of elongate-flattened forms. But when over-increase comes to entail extinction, variations in the direction of optimum orientation of the plane of division will accumulate through Preponderant Survival;<sup>2</sup> and when nuclear substance appears, that optimum will lie in such orien-

<sup>1</sup> Cf. Bütschli, *Ueber Schäume*; abstracted by Dolbear, *Woods Hole Lectures* for 1894.

<sup>2</sup> Preferred to "natural selection," as expressing nothing but the facts, and avoiding implication of selecting agency; also, as available equally in the form, Preponderant Extinction, which emphasizes the real

tation of the division-plane, as entails equal substance in each daughter-cell.

Paradoxically, defeat of "spontaneous generation," furnishes an argument in its favor. To-day it might be impossible for "life" to develop *de novo*, unless under artificial conditions; but why? Because the necessary forerunners, the long series of gradually complicating molecules, would be destroyed by microorganisms. So accustomed are we to this result of their activity, that we speak of "easily decomposable substances," forgetful that there are no more stable compounds than these same, in the absence of an efficient cause for their decomposition; and the myriad laboratory and commercial sterilizations prove that the only such cause is activity of microorganisms, no combinations of physical energies, sufficing. But such compounds never breaking down "of themselves," the period antecedent to the emergence of "life," may well have been one of progressive complication of carbon molecules; for, decomposing agencies absent, such molecules may have remained unaltered indefinitely, till change in environmental conditions led to further complication, however delayed the advent of that change may have been.

Among these earliest forms, variations toward increased rapidity of growth and a prodigious prolificness,<sup>1</sup> would accumulate, provided with such variations there did not happen to be associated others overbalancingly contra-adaptive ("unfavorable"). But variations in the direction of rapid growth and reproduction do not exclude other variations, simultaneous or successive. Consequently, individuals predominating numerically in virtue of prodigious prolificness may perpetuate variations arising haphazard (*de facto*, from unknown causes), till, sometime, those variations either (1) disappear, or (2) become functional through (a) increase in size, or (b) emergence of some new haphazard variation which with the previous such variation, constitutes a combination having survival value. But, become functional, the previous variation, *viewed retrospectively*, is termed an "incipient structure," a name convenient enough if it do not imply difference between the variations which emerge only to disappear, and those which emerge later to increase. Both are alike variations, and subsequent disappearance of the one set, and subsequent elaboration of the

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factor, "selection" of some organisms, really meaning their presence as living representatives, by reason of extinction of the remainder. But having most to do with living forms, the affirmative phrasing will be most frequently used.

<sup>1</sup> Here, prolificness refers only to number produced (fecundity); not to proportion surviving to maturity.

other, are equally incidents of prevalent environmental conditions.

In the beginning, successive integrations of structure must have been limited to accumulation of haphazard adaptive variations; especially would haphazard *combinations* of adaptive variations accumulate. At first,<sup>1</sup> such combinations must, on the doctrine of chances, have been exceedingly rare; and consequently, only among innumerable progeny of prodigiously prolific individuals, would they occur in sufficient number. Their elements need not, however, have appeared simultaneously, if one element were sustained by the carrying power of prodigious prolificness, till such time as the other (or others) appeared.

Organisms, then, first predominating numerically by reason of prodigious prolificness, might come later to survive preponderantly (be "selected") in virtue of other characters originally acquired incidentally. But sprung from prodigiously prolific forms, such organisms would, nothing opposing, remain prodigiously prolific,—whence, the condition exhibited by protozoa and protophyta: adaptive reactions and structures in combination with enormous prolificness, the last considered adaptation to conditions involving enormous extinction, though it is perhaps not only (and possibly not mainly) referable thereto, but may be a relic of the original sustaining factor.

Probably the characters considered distinctive of "life" did not emerge all at once; the primordial organisms most likely possessing metabolism only, eventuating in increase of mass ("growth") and reproduction. But the advent of carnivorous metabolism may have been long delayed. Whether that advent ante-dated, accompanied or post-dated that of motion, is indeterminate and relatively unimportant; combination of these activities opens up the illimitable vista of the struggle for existence with its incidental outcome, preferential survival of particular individuals.

Motility may have emerged through accumulation of haphazard variations. If among innumerable offspring of prodigiously prolific individuals, some varied in the direction of greater tremulousness of the protoplasmic jelly, and if among offspring of these individuals such greater tremulousness persisted indefinitely, till later (one or a million years) in some tremulous individuals, variations arose in the direction of correlation of tremulousness into reaction to impact of energies ("stimuli"), such oriented tremulousness would be "motility,"

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<sup>1</sup> At first; progressive preponderant survival of individuals in which adaptive combinations have, *de facto*, arisen eventuates in a race prone to emergence of such combinations.

the problem in the origin of which seems not so much that of change of form, as association of such change into reaction to impinging energies. But capacity for response to environmental happening being the only element in external reactions of survival value, and accuracy of response the final measure of that value, variations in the direction of greater accuracy would accumulate; variations, that is, in the direction of integration of structure, in proportion as they conduce to such accuracy, to improved sensori-motor connections.

Accumulation of haphazard variations thus eventuates in integration of structure to a point at which the organism becomes able to react adaptively to recurrent environmental happening; when, perfect adjustment reached, modification ceases. But subsequent change in environment will entail consecutive change in habitant organisms, via the same process,—accumulation of haphazard variations adaptive under and to the new conditions. As with linking of variations into combinations, so with linking of new variations on to those combinations, the process must have been exceedingly slow, dependent as it was upon emergence of variations, and extinction of the vast host not possessing them; and only among offspring of the prodigiously prolific would sufficiency of variations occur.

But with every winnowing out of individuals unpossessed of survival-requisite variations, the "successful" remainder comes to be more and more exclusively made up of individuals in which environment-responsive variations have, *de facto*, emerged; therefore, of individuals more uniform in type, as being out of many the particular ones which happened to coincide in adaptation to common environment. An incidental outcome of successive winnowings must then be an ever more pronounced and apparent definiteness of evolutionary trend, series ever narrowing into closer conformity with environmental conditions, necessarily eventuating in an environment-parallel race. And the evolution of that race will thenceforth exhibit a definiteness of trend in keeping with whatever definiteness of trend happens to obtain in environmental conditions. Whence, no presumption of a "plan of evolution" (equally none as to design in the universe) is inferable from this definiteness (secondary and derivative) of biological trend, however successfully or unsuccessfully it may be inferred from the parental definiteness of environmental trend.

Prodigious prolificness involving frequent re-divisions of the protoplasm with corresponding brevity of the nutritive stage, precludes growth to larger mass. But when the original numerical predominance of prodigious prolificness gives place to preponderant survival in virtue of integration of haphazard adaptive variations into combinations (capture and digestion of

prey), further accumulations of such variations, in the direction of increased surface (digestive), may eventuate in larger mass with its ulterior possibilities in the way of differentiation of structures. More abstractly, the carrying power may come to pass over from the prodigious prolificness to the adaptive combinations, obviating previous hindrance to growth to larger mass.

From the prodigiously prolific mass whence descended our protozoa and protophyta, variations accumulated, *de facto*, along two main lines, eventuating in plants and animals. The momenta (organismal dynamic factors) determining trend of evolution along the plant line, seem to have been those previously operative,—successive emergence of haphazard adaptive combinations sustained by a prodigious prolificness. For the momenta distinctive for plant evolution are: Enormous expansion of surface in association with fixed habitus and hard protective structures, and relatively prodigious prolificness, eventuating in larger mass; with, probably, proneness to emergence of adaptive combinations, bespeaking descent from individuals in which such combinations had, *de facto*, been wont to occur. At least greater frequency of “sports” in plants, and the fact that most if not all asserted cases of genesis of new species come from botanists, speak for this view.

The momenta determining trend of evolution along the animal line are: Moderate expansion of surface, such sufficing in virtue of association with active habitus, the latter sustained by emergence of structures admitting of alternate and multiple uses of the same organ and of “profiting by experience,” eventuating in larger mass; and, following the advent of the psychic factor, progressive decrease in prolificness in connection with an ever-increasing capacity for self-protection, securing of the opposite sex, and care of offspring, summing to a continually rising multiplication rate. Otherwise put, the sequelæ of the emergence of the psychic factor were a steadily increasing tendency to readjustment of survival values, toward a shifting over from survival of the more prolific to that of the more intelligent, and an incidental outcome, integration of “mind,” has been the steady trend toward individualization.

## CHAPTER II

### NEURODYNAMICS

Neuromolecular readjustments consecutive upon environmental happenings, whereby optimum motor response to such happenings comes about; optimum as regards kind, intensity, and rapidity of response. Interpolated inquiry whether nerve energy is electro-chemical. Parallelism between reactive effect of heat in the electric circuit upon the conductor, and that of consciousness-*di* upon nerve substance; indicating the *modus operandi* of consciousness as neither dominant

nor epiphenomenal but reactive-dynamic, and further indicating the nature of consciousness, its mode of genesis out of nerve energy, and its subliminal recession as incidental to its expenditure in intra-molecular work,—all in harmony with the conservation of energy.

In way of external nervous reactions, the one *sine qua non* for survival is accurately adjusted motor response to environmental happenings. Loosely termed "profiting by experience," such adjusted response is the outcome of several neurological processes, interblended and separable only in analysis. But clear understanding of reactions ("actions") of animals, can be attained only through preliminary analytical separation and ultimate synthesis, of these processes. Motor response can become adjusted to happenings as regards kind, intensity, and rapidity, of response.

*Adjustment as regards kind of response.* The following are involved :

Depositional-registrative processes :

1. Registration of environmental happenings. *Imprintation.*

The real type, of which 1 is an abstraction, is, however,

- 1 a. Registration of imprints, *chained in series*, consequent upon environmental happenings chained in series. *Serialization.*

Resuscitative-interpretative processes :

2. Appreciation of environmental happenings *as having been experienced before.* *Recognition.*
- 2 a. Appreciation of environmental happenings as having been experienced before, not as individual happenings, but *as members of a chained series.* *Diagnostic recognition.*

All these processes find explanation on ground of that property (variation in resistance with temperature) of conductors, in virtue of which mere passage through them of the electric current entails change in the *future relations* of current and conductor. And with a current dividing itself among several carbon conductors, the ultimate distribution will be different from the initial distribution, a disproportionate amount of current coming to pass via those conductors which, originally offering greatest resistance, suffered most heating. True, there is no evidence whether with carbon itself, one passage of the current would entail lessened resistance for subsequent passages (initial temperatures equal). But that with certain carbon compounds, one passage might entail lessened resistance for subsequent passages, follows from Spencer's conception of the colloid molecule as one in which complexity of play and cross-play of the intra-molecular forces is so great as to induce molecular sluggishness (inertia, viscosity, so to speak), a con-

dition in which change takes place less readily and goes less far than with crystalline molecules under like conditions of impact; but likewise, as with a molecule in which, change once occurred, return to the original condition is correspondingly difficult and imperfect, the molecule retaining some imprint of its experience. Whence, here we reach the origin of "genetic" (irreversible) series, the philosophic import of which can, therefore, be no greater than that attaching to the underlying physico-chemical change in the substrate. But among the carbon molecules manifesting such *plasticity*, those exhibiting "life," are the ones in which it is manifested in highest degree, and among these, the molecules forming the nervous substrate are the ones in which it is manifested in highest degree of all.

Of the above catalogued processes, the plasticity of the carbon molecule explains Imprintation and Serialization,—the former, as transit of energies through such molecules modifies them for subsequent such transits; the latter, as mechanisms once associated in action are thenceforth interconnected by an imprinted line of lessened resistance.

Respecting Recognition, recalling Spencer's conception and such phenomena as isomerism and polymerism, we may picture flow of energy through the nervous system thus: Impinging energies in undergoing absorption, entail unequilibrium in the peripheral sense organ, eventuating in a nerve "impulse." Concerning the nature of this, if one will have any working hypothesis (any principle of coherence among his ideas, that is), but one is possible in the present state of science,—nerve impulses are *some* form of undulatory energy. Among known forms of energy, their affinities being closest with electricity, electrical phraseology is admissible, pending emergence of inconsistency or *reductio ad absurdum*. Depicting the changes ensuing in an undifferentiated neurone<sup>1</sup> upon the advent of nerve-impulse waves, potential accumulating to the irruption point, discharge along the neurone occurs, under resistance, entailing emergence of heat which reacts, bringing about such modification of orbit form (vibration system) of the unit-molecules of the neurone as corresponds to diminished resistance (say the ellipsoidal). On account of the unwieldiness, sluggishness and viscosity of the molecules, reorientation of orbit form is at first slow and imperfect, and on cessation of stimu-

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<sup>1</sup>Nerve cell plus "fibre;" unit of nervous architecture. The neurones of the intervertebral ganglia extend, one process down to feet, the other up to the medulla. The neurone theory is here used for convenience of presentation; present speculations are not dependent upon it for their validity, much of this line of reasoning dating back to the days of the vaguer "tracts."

lation, the orbit form swings back toward the original figure (say spherical), return being, however, incomplete. But with each recurrence of similar stimulation, the orbit form becomes warped further in the same direction, and every back-swing is less.

While subsequent conduction thus becomes more easy for the same stimulus, it becomes less easy for stimuli of other type; for orbit forms modified in one direction will be less susceptible of modification in other directions than will original unmodified orbit forms,—the experience-imprinted molecule becomes specialized.

Though sometimes, Recognition is not necessarily (or even generally) accompanied by consciousness; most movements being automatically adjusted, *e. g.*, proportioning of pulls of the various leg muscles to unevennesses of the ground. But such proportioning presupposes Recognition as an indispensable interpolation in the sensori-motor progress. How explain such automatic proportioning? On sensory stimulation, nerve-energy waves surge up to the terminal arborizations of the first tier of afferent neurones where they heap up a certain "gradient."<sup>1</sup> If, now, nerve energy be some form of wave motion, different varieties of that energy (those initiated by light waves of different lengths and eventually arousing different sensations) may be assumed varieties of such motion, with different lengths or different vibration rates. And the only explanation accordant with accepted scientific theory, of the better conduction along previously used routes, is that it is a phenomenon of harmonic-vibration type, and the non-conduction along routes otherwise specialized, a phenomenon of interference.<sup>2</sup>

If, then, among the innumerable molecule-chains constituting the second tier of neurones, one has through repeated im-  
 printation under the influence of identical (perhaps also of nearly identical) stimulus waves, become specialized for transmitting them, they will outflow along that neurone in preference to others, not necessarily that they might not eventually have heaped a gradient steep enough to admit of their irrupting into those others, but because *at a time antecedent* to that at which such gradient could be attained, a gradient was

<sup>1</sup>"Gradient" for consistence of phraseology; "unequilibration," less specialized, would answer as well.

<sup>2</sup>I have seen in successful operation a device for calling at will any particular subscriber on a "general circuit," consisting of armature-tipped metallic reeds, one at each subscriber's, and at the telephone exchange duplicate reeds, each attuned to unison with that of one subscriber. When the electric current was switched through any reed, only the bell of the subscriber with the correspondingly attuned reed, rang, interfering pulsations preventing transmission of current through the other reeds.



reached at which the specialized neurone was "permeable." Specialized neurones are, thus, the *antecedently permeable*, meaning thereby that to every increment of rise of potential, there corresponds a vast number of approximately permeable neurone-conductors, and the one among the many possibles which a particular wave enters, is that permeable for it at lowest (first-reached) potential. But, discharge having occurred along the lowest-potential route, such further rise of potential as might have admitted of irruption into less permeable routes, is precluded. Antecedent permeability is the key to conduction-conditions everywhere throughout the nervous system, and it means that with every flow of nerve energy, certain preferential routes will be followed. But this is Recognition, Diagnostic Recognition, the essence of which is *discriminative* preferential conduction, discriminative with respect to the shunting of the initial member of a stimulus-series into the route traversed by its identical (or closely similar) predecessors.

If the stimulus be an unhabitual one, no specialized neurone existing, potential will rise to a gradient at which irruption can take place into an unspecialized plastic neurone, the resistance of which, though greater than that of a neurone specialized for a particular stimulus, for that stimulus, is less than that of a neurone so specialized for a stimulus other than its own.

*Adjustment as regards rapidity of response.* But the only direct value of the nerve apparatus in the struggle for existence being its ability to fore-parallel environmental happenings, admitting of protective reaction not to the happening of the moment, but to its coming sequels in advance of their advent, 2 and 2a (an analytical abstraction *en route* to 2b) have no survival value except as they enter in 2b.

Accelerative processes:

2b. Appreciation of environmental happenings as having been experienced before, not as individual happenings, but as members of a chained series, *the remaining members of which are yet to come—Diagnostic Recognitive Fore-triangulation.*<sup>1</sup>

But the value of this process would be rather limited, did not an identical one occur on the motor side.

3. Ability to execute more rapidly movements performed before—*Agilization.*<sup>2</sup>

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<sup>1</sup>Hereafter termed *Anticipations; Expectations* of Huxley (*Life of Hume*).

<sup>2</sup>The essential features here are: Increase in rapidity and in efficiency (co-ordination plus power), which we observe increase *pari passu*. "Greater ease upon repetition" is the same thing in psychical terms.

But happenings varying widely in exigency, only organisms can survive which have become able to fore-parallel environment. Neurologically, increase of rapidity upon repetition is the outcome and expression of a progressively decreasing time-consumption upon subsequent, as compared with that upon the initial passage of the nerve-energy current, in reorienting the viscous, sluggish, unwieldy molecules, which undergo reorientation *seriatim* through, and only in proportion to, heaping in the first molecule, of potential to a point at which latentization takes place, whereupon a certain amount of reorientation of that molecule ensues, admitting of passing on of the current, in quantity, to the next similar molecule, in which the same process then goes on.<sup>1</sup> The time-consuming element in the process is the latentizing, which necessarily takes place constantly at expense of potential.

This explanation of increase in rapidity is supported by parallelism between progressiveness of that increase, and that of the attendant psychic phenomena ("greater ease" and diminished vividness of consciousness), to which latter the foregoing explanation is particularly apt.

But imprintation makes for rapidity, not only by impressing the reorientation-habit upon successive molecules of one neurone, but more by perfecting inter-neuronal connections ("associations"), and most of all by entailing the turn-table reorientability of the plasticity zone (which ensures concentration of conduction indispensable for rapidity), and replacement of conduction via conscious, by conduction via reflex tracts. But all these are incidental and inevitable step-by-step elaborations of the one process of molecular reorientation-imprinting.

But when rapidity of conduction along the happening-indented, environment-parallel imprint-chains comes to exceed the rate at which happenings succeed one the other in the environment, on advent of stimulus annunciative of happening *a* of the happening-series *a-n*, the entrant waves sweeping along the much-imprinted nerve trellis-work ahead of the drama-development, before the advent of the stimulus annunciative of *b*, the organism is already fore-reacting to the impending threat inherent in *k* ("instinctive warding off"). But this is Diagnostic recognitive fore-triangulation and Agilization. When accompanied by consciousness (not at all necessary), the process is heralded as "fore-knowledge" (fore-imaging), but conscious or unconscious it equally consists, in

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<sup>1</sup>O. J. Lodge (*Internat. Monthly*, 1900 (May), I, p. 495) takes essentially the same view (as far as this point goes), thinking conducting substance comparable to a series of condensers, charged *seriatim* to full capacity; and this is, likewise, his explanation of rate of transmission. His "capacity effect" is my "reorientation."

essentials, in resuscitation of fossil experiences imbedded in the imprint-chains, and eventuates in repetition of the motor response which, *de facto*, sufficed in former emergencies.

#### INTERPOLATION: IS "NERVE"-ENERGY ELECTRICAL?

Eccentric, bizarre theses apart,<sup>1</sup> nerve energy is a kinetic species, either distinct from all, or identical with some, species operative outside the body. So long as it is conceived as a species of the energy genus, interchangeable with other species at exact (as yet undetermined) equivalent, the difference between the alternatives is not fundamental; still they have very unequal merit. If one elect the first and, without the necessity being proven, begin multiplying energy-species, where will he stop? If "nerve" energy shall be a distinct species:

*Hypothesis.* Difference in microscopic structure and in function constitutes a valid criterion of distinctness of associated energies, or—

*Hypothesis.* Such difference does not constitute such a criterion.

On the first, nerve, muscle, gland (etc.) energies are distinct kinetic species. But if to every large difference in structure and in function corresponds difference of species, for minor (but well-marked) differences must be admitted varietal differences; four varieties for the connective-tissue group, three for the muscle group, two for the nervous system,—more for glands, mucous membranes, etc.

The second hypothesis avoids this confusion, leaving clear way for assuming the foregoing factitious species and varieties to represent extra-corporeal energies, here peculiar in *facies* by reason of peculiarity of substrate; an assumption in accordance with all known facts. For, intra-corporeal heat, electricity, light, differ in no wise from extra-corporeal; and every chemical advance makes increasingly manifest the identity of intra-corporeal with extra-corporeal chemism. And the substrate which, in homologous muscles in allied genera and other muscles in the same fish, generates "contractile" energy, is in certain muscles of some fishes modified to an electricity-generating substrate.

<sup>1</sup> As that nerve energy is a Something-not-energy. Our meek patience with vagaries where consciousness is concerned does not extend to such theses *in re* nerve energy; and fondly we hope the "philosopher" of the future will be limited to the alternative of admitting consciousness to be, or of denying that nerve energy is, a kinetic species. Whoso wills to maintain the latter must explain:

1. Potential energy of food excluded, *ex hypothesi*, from serving as source of this Something-not-energy—(a) whence is this Something derived in embryo, from spermatozoon, ovum, or both? (b) in growth from embryotoadult, what is its source of increase? (c) from what source is it kept up from day to day?

2. (a) On the assimilative side, where do ordinary forms of energy cease to give place to this Something? (b) not interchangeable with, what is the relation of it to, ordinary forms of energy, and their relation to it; and how is the equation of the conservation of energy within the living body, all at loose ends, to be knit up? (c) on the dissimilative side, where does this Something cease to be, and ordinary energies again come into play, and what is the destiny of this Something after it has done its work?

3. Are nerve, muscle, gland (etc.) energy merely different modes of manifestation of one Something-not-energy, or distinct Somethings-not-energy? If the former, then muscle energy being in some cases demonstrably electro-chemical, the case falls. If the latter, heavy *onus probandi* lies on the asserter, to show wherein the case for nerve energy differs from that for muscle energy; and if histological differentiation shall serve as criterion of distinctness of Somethings-not-energy, to show where multiplication of such Somethings is to stop (striated-muscle Something, smooth-muscle ditto, heart-muscle ditto, and what not).

"Trivial!" I think it is myself, but for outspoken declaration that consciousness is Something-not-energy, yet can control energy, see Minot (*Pop. Sci. Mo.*, 1902, lxi, 289-303.)

Eccentric bizarre theses apart<sup>1</sup>, the hypothesis on which one can correlate ("explain") most facts with fewest difficulties, is that nerve energy is electro-chemical-electric,—meaning consisting of waves of electric (or near-electric) type, set going in the sense organs by stimuli, which waves excite in nerves (perhaps mostly in the cells) chemical changes generating tributary reinforcing similar waves.

To the view that nerve energy *may be* electricity adequate objection has never been made. Difference in speed has been appealed to; *meaning* difference between speed of nerve energy in nerve, and of electricity in wire. Speed of electricity in nerve has never been measured (how could it be?); what has been measured is speed in nerve of an electrically generated nerve impulse. But transit of electricity through a series of sluggish, unwieldy, viscous molecules which have to be reoriented (via the heat effect) *seriatim* as it goes along, presents a condition not at all comparable with transit along a wire.

Also, nerve energy is said, unlike electricity, never to cross a gap (between apposed proximal and distal ends of a severed nerve). Even if undisputed, this would not necessarily invalidate the theory of identity; too many elements of uncertainty existing (impossibility of excluding diffusion of current around cut ends, improbability of apposition of original neurone segments when the cut ends are brought together). Further, the only way that, in view of the phenomena of electric currents in nerve, the natural inference of the identity of nerve energy with electricity has been staved off, is by asserting (very probably correctly) that the currents are "currents of injury," the outcome of changes taking place over the exposed cut ends of the nerve. But this explanation cannot be worked double; if the cut ends are sufficiently altered to generate "currents of injury," they may well be so altered as not to transmit nerve energy. Finally, cases of rapid restoration of function have been accumulating in recent surgical literature to an extent to render it probable that the whole question of non-transmission across a gap may yet come up for re-hearing with the ultimate verdict in doubt.

If nerve energy be electrical, everything clears up,—its source is the chemical energy of the food, it enters the equation of the conservation of energy, it can induce muscular contraction as electricity induces such contraction. Moreover, its latentized form (the psychic aspect of which we know in and as consciousness) reacts upon nerve molecules as the similarly generated by-product of electricity, heat, reacts upon carbon molecules. Consciousness here finds no mere analogy, but a true homology of relations, and its first parallelisms of relations, former comparisons being mere fanciful illustrations, ikons to assist the imagination of the vulgar to "understand" unintelligible things. The homology may be thus shown:

<sup>1</sup>As that nerve, muscle, gland energy are merely different manifestations of "vital force."

*Hypothesis.* "Vital force" is Something-not-energy.

*Hypothesis.* "Vital force" is a kinetic species.

The first requires answer to all questions in note, p. 77; and, in particular, explanation how in electric fishes muscle Something-not-energy can be replaced by electricity.

Though the second seems expressly designed unerringly to miss every advantage and infallibly to catch all difficulties in the situation, though exceedingly improbable (almost demonstrably false); so long as things fall within the equation of the conservation of energy, we, become old and patient, might make shift to live with it, cursing it roundly for the clumsiest contrivance it was ever our ill-starred fortune to meet.

## Electricity

Working against resistance,  
heat emerges.

Heat diminishes resistance in  
carbon molecules.

In such molecules, the heat of  
the electric circuit tends  
to eliminate itself.

Better conduction is the result.

## Nerve Energy

Working against resistance,  
consciousness emerges.

Consciousness diminishes re-  
sistance in nerve (carbon)  
molecules.

In such molecules, conscious-  
ness tends to eliminate  
itself.

Better conduction ("profiting  
by experience") is the re-  
sult.

*Adjustment as regards intensity of response.* But how do the resistances become so nicely graded as to account for all the minutiae of adjustment observable? Environmental happenings differing widely in violence, only organisms can survive which come to be able to react to different such happenings with very different intensities of motor response; horses must not waste on escape from flies energy needed for flight from the wolves, salmon bound up-stream on sexual mission must expend every kinetic unit to surmount the cascade. That is, graded happenings must be met by graded response. But intensity of response is determinate as (variations in intoxication-condition apart) the result of the kinetic outpour of the plasticity zone. That outpour is, however, determinate, as the resultant, in magnitude and direction, of the forces undergoing fusion (superfusion, etc.). But those forces are determinate, as resultants of amount of nerve energy entering, and of its lines of transmission within the plasticity zone; these factors involving (as dependent function) liberation of a determinate amount of energy by the cell elements of that zone. Amount of entrant energy and lines of transmission are, however, determinate; amount as a dependent function of intensity of stimulus, lines as quotients inversely proportional to the resistances. Whence, graded motor response can come about only through grading of intensity of stimulus, of resistance, or of both. But, being environmental, stimulus is for the organism a fixed quantity and ultimate factor; consequently, graded response can come about only through grading of resistance. And stimuli being graded, it must come about. For, among carbon molecules differing in initial resistance and capacity for ultimate modification, preponderant survival will occur of individuals offering the optimum, which will lie where initial resistance suffices to develop just the amount of heat which will reduce resistance to optimum conduction, measured in terms of final oecological value, motor response; just that heat which will expend itself in intra-molecular work. For, if by reason of too small, or by reason of too great, initial resistance, heat relatively insufficient emerges, conduction along that molecule-chain will be deficient, eventuating in deficient response. Contrariwise, heat relatively too great will entail unduly great conduction along that particular molecule-chain and consequent disproportionately great response of certain muscles (inco-ordination).

So far, the hypothesis demands a separate molecule-chain for every intensity of every stimulus. But biological economy (most needed in the brain with whose rapidity of enlargement the fundamental process of bone-development in cartilage has been unable to keep pace, whence cranial-vault development in membrane) suggests that each molecule-chain may transmit several (or many) intensities of stimulus; that each chain has a certain polyvalency.

### CHAPTER III PSYCHODYNAMICS

I. Factors Determining Direction of Energy Flow: Fundamental dynamic constitution of nervous system (stable factor); its persistence temporarily, spatially, zoologically. Intoxication condition of nervous system (labile factor); principal variations in reaction type. Stimulus (environmental, annunciative factor).

II. Cortical-Psychic (Conscious) Activity: No thaumaturgy, but biological resultant contains reactive as well as incoming components. Phylogenetic divisions of cortex. Bioneuropsychodynamic relation. Definition of consciousness-facies,—sensation, thought, feeling; their differences referable back to differences in underlying arousing conditions; their respective dynamic rôles. Law of lapse, of fade. Taxonomic importance of lapse.

*A, Pre-Compositional:* Non-lapsing facies take rise in elastic-molecule structure. Sensations, non-lapsing by reason of biological necessity for space representation; latter, outcome of interproportionment of simultaneous sensations parallel with interproportion of arousing stimuli. This requires constancy of resistance in sensation area; which constancy ensures projection forward into coming composition of forces, of stimulus waves environment-representatively interproportioned. If nerve energy is electrical, heat-generation in nerve circuit is directly as energy-radiation in environment, fulfilling biological necessity for environment-representation in cortex; comparison of Fechner's with electric-heat formula suggests his constant measures resistance of sensation area, his logarithmic function judgment-coefficient from distance-relations of moving objects, and correlation of psychic-inseparable with dynamic-inseparable on basis of increment for increment. Inheritability; Baldwin-Osborne-Morgan "factor" superfluous. Consciousness penultimate-philosophically.

*B, Compositional:* Plasticity-zone action divisible into Route, Fusion-Composition-Reorientation-Psychogeny; repetition of previous activity except for differences the outcome of imprints or of variations in "functional condition." The last apart, Route is strictly a dependent function of imprintation conditions; determines character of reactive forces but not their amount. Fusion: Abutment area; inequality of imprintation inevitable outcome of unequal frequency of happenings, leads to formation around abutment area, of fusion focus. Imprintation along intra-, exo-, and extra-focal routes, contrasted. Attuning of molecular orbit forms; reciprocal modifying action of wave on orbit form, of orbit form on wave. Beginning reconcentration involves fusion. Composition of forces: Only another side of fusion; amplitude of fusion wave sum of intensities of component waves. Superfusion-supercomposition. Reorientation: Incident to fusion-composition; its essence, dynamically, redistributions in kinetic field whose outcome is optimum motor response.

*C, Concurrent-Compositional:* Given sensation (space-orientation) and feeling (reaction-regulating) ingredients, organisms could oppose appropriate response to happenings; reaction-sequences *sine qua non* for existence could come to be motivated through adjustment of second factor, via Preponderant Survival. Feeling and thought independent variables; their respective offices; that of feeling, rendering of tracts temporarily reflex, ensuring, without fatigue, certain prompt performance of sequences too long-lasting and complicated for execution via reflex action. Alternative, that migration-sequence thought-motivated, untenable. Thought, *the* prophetic sense. Introspection and self-consciousness. Allocation of feelings, to motor area or special affluents of it. Independent of intensity of stimulus,

feelings cannot be "in the sensation;" not lapsing, cannot take place in thought tracts. Sensations presumably tributary, some to pleasantness, some to unpleasantness, tracts. Dynamic interrelation of feeling and thought tracts; probably former on resistance-plateau accessible to energy-inflow when intoxication lowers resistance; while energy can flow from feeling to thought tracts, reverse flow contingent on intoxication-lowering of resistance. Relative permeability of feeling and thought tracts, outcome of accumulation toward optimum intoxication conditions and optimum plasticity, respectively.

III. Infra-Liminal ad-Cortical and ab-Cortical Neurones: Constant but low resistance; composition cannot take place by reason of biological necessity; this molecule type probably phylogenetically the older.

#### I. FACTORS DETERMINING DIRECTION OF ENERGY FLOW

The factors determining large fluctuations in energy flow, are divisible into two classes,—those which go to make up the selective receiving capacity of the nervous system, and those which fall under the head of annunciative value of stimulus. The first comprises a constant and a variable; the former being the fundamental dynamic constitution of the nervous system in the species (smaller or larger zoölogical group), the latter, the intoxication condition of that system at any given moment (the two summing to the "functional condition" at that moment). The actual reaction of an individual will then be the resultant of one constant and two variables; and we might epitomize, paradoxically, the respective shares by saying that the fundamental dynamic constitution determines form of reaction, subject to the qualifying effect of a "predisposing cause" (intoxication condition), and the dominant rôle of the "exciting cause" (stimulus).

*Fundamental dynamic constitution of nervous system.* To the operation of this factor are referable those reactions (consequently also, the habitually preter-active reorientation proclivities necessarily precedent thereto) which are approximately constant in an individual from age to age, season to season, and especially those common to him and others of the same species (particularly of the same sex) or narrower or wider zoölogical group. Examples: The herbivorous and carnivorous habits, and a chain of habits tributary to the latter (lying in wait, chasing, seizing, killing). The essential characteristic of the reorientation-proclivities referable to this factor is persistence in space and time; over large zoölogical groups, wide areas, and (inferentially from fossil structure) extensive periods of geologic time. This factor is, thus, the element in animal reactions, which makes for stability.

*Intoxication condition of nervous system.* The most striking characteristic of animal (especially human) reactions is caprice-like super-variability often defying successful prediction and leading to belief that they are "free," though they conform

closely to the law of the average.<sup>1</sup> Of late, fore-falling shadows of the deterministic hand on the wall, have led to much subtle trimming as to just how free, "free" is. Leaving that to those interested, apart from fatigue (in which diminished activity in unduly used mechanisms incidentally involves shift over to other mechanisms), nothing yet brought forward sufficiently explains this pre-eminent variability. But fatigue represents one case of a wider category, the intoxication condition of the nervous system, the sum total of the *chemical* forces acting on the organism. These embrace habitual and unhabitual products of metabolism, habitual saline intake; secretions of glands (sex, adrenal, thyroid, pituitary); products of micro-organisms (toxins, ptomaines, leucomaines); and the motley host of unhabitual chemicals called "drugs." The two-sided relation involved in emergence of consciousness explains similarity of psychic action of substances widely remote in composition; some intoxicants supposably increase or decrease nerve energy, some increase or decrease resistance, and some act simultaneously on both factors in the same or opposite directions, whence the possibility of all necessary combinations of effect.

To the operation of this factor upon the fundamental dynamic constitution are referable those reactions which vary from sex to sex and season to season; and many of those which in one individual vary from age to age, moment to moment, and from conditions, of health to those of disease. This factor is, then, the psychic variation-inducing factor, *par excellence*. The following comprise the principal variations in reaction type:

Variations from sex to sex: Everywhere observable (collection of instances in Darwin's *Descent of Man*). Throughout the vertebrates, the male exhibits mental attributes summing to aggressiveness, whether in combat or the sexual pursuit; whereas the female shows a relative backwardness, qualified by the periodic emergence of "mother-love." All psychic characters being more apparent the greater the mental development, these variations are well-marked in the human, and have given rise in all peoples to sexual-social customs and rituals reaching extreme elaborateness. These variations are explicable as the outcome of unisexual intoxication.

Variations from individual to individual: These are seen in all animals including man, in which in connection with greater brain development the "principle of individualization" attains most marked expression. Some are addicted to gastro-intestinal matters; others turn from these to respond to sex stimu-

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<sup>1</sup>Cf. Morselli, *Suicide*. Yet if any act be "voluntary," suicide is that act.



lation; still others recoil from this to engage in its artistic or religious equivalent; while some react only to a particular congeries of stimuli ("hobby") entirely peculiar to themselves.

Reactions strictly personal to the individual and constant in him from age to age, season to season (etc.) are referable to his *Anlage* and mostly to the fundamental dynamic constitution of the nervous system.

Variations from age to age: Under this head come reactions in connection with dependence of offspring upon parents, protective concealment of defenceless young not cared for by parents; and the predominantly gastro-intestinal and motor interests of the young, in contrast with the sexual and later parental interests of the adult. These variations are referable to age variations in intoxication conditions, whether in the way of surplus or deficit, except where they are the outcome of imprintation ("experience").

Variations from season to season: Seasonally recurring ruttings, combats, migrations, abstinence from food on migration, are among a host of instances. These are referable to seasonal variations in intoxication conditions.

Variations from moment to moment: These are continually observed, especially in the young ("distractibility"). Most of these are in reaction to the perpetually shifting environmental stimulus-succession; but the hour-to-hour variations ("moods") into which the moment-to-moment changes are in-woven, are, in my experience, largely the outcome of shifting intoxication conditions.

Variations from health to disease: These range from restlessness of fever to wildest delirium or to deepest coma; from the normal feeling of well-being, to the delusions of grandeur of parietic dement or to the unrelieved gloom of the melancholic. Many of these variations are now recognized by medical writers as due to intoxications.

Finally, marked change in mental condition frequently follows critical discharges (colon lavage, ejaculation, abscess evacuation, etc.).

*Stimulus.* In what sense can kind and intensity of stimulus be said to enter as elements in determination of form of reaction and of reorientation precedent thereto? Any classification of stimuli from the standpoint of their reaction-evoking (re-orienting and psychogenic) action will be incommensurate with classification based on their physical or chemical properties. This is exemplified by difference of reaction of different nervous systems to the same stimulus, the visual stimulus-complex, "cat" evoking promptest reaction from a mouse, none from a by-standing cow. Still, this incommensurateness

does not mean that reaction-evoking (reorienting, psychogenic) action of a stimulus is independent of its kind and intensity, but that these attributes enter as elements of effectiveness not by reason of their physico-chemical values, but only as they are necessary elements toward identification; toward Recognition, of the stimulus as one experienced before, as a member of a chained series, the remaining members of which are yet to come. Effectiveness of stimulus thus corresponds to an *ecological* value, the annunciative power. This value, however, bearing no direct and definite, but only an incidental relation, to the physico-chemical properties of the stimulus, reorienting (reaction-evoking, psychogenic) capacity of stimulus is not, properly speaking, a dependent function of stimulus at all, but is an adaptive acquisition (susceptibility) of the organism.

## II. CORTICAL-PSYCHIC (CONSCIOUS) ACTIVITY

We now approach the psychologist's ultima thule; his holy of holies, presided over by Vishnu-Ego, to whom the brain submissively hands up all the data received by it from the sense organs, and Who, having duly deliberated thereupon, vouchsafes to Its neurone-minions Its behests. We shall, however, find no something-from-nothing device; but only that the final mechanical resultant discharged is not the mechanical resultant of the incoming forces of the moment alone, but a resultant into the composition of which enter, *as components*, certain other, reactive forces, contributed by the organism itself. These forces represent no necromantic thaumaturgy, but merely the static forces (partly rheostatic, partly reactive-dynamic) of the organism, accumulated through Preponderant Survival; forces which contribute to determine the only form of reaction of which its particular structure is capable.

*Phylogenetic Divisions of Cortex.* In man, the association tracts have wedged far apart (yet bridge over the hiatus between) two great brain segments, the sensory and motor areas. But as we descend the zoölogical scale, this intrusive wedge narrows up and practically disappears, and we reach the original state of approximation. Consequently, the cortex comprises the following regions:

Palæogenetic.

Sensory area.

Sensori-motor bridge.

Motor area.

Neogenetic.

Association tracts (as developed in higher vertebrates).

But "association tracts" being used in an unduly wide sense, the term *plasticity zone*<sup>1</sup> will hereafter be used.

*Classification of Consciousness-Facies.* The first requisite for understanding of mental action is trenchant distinction between mental process and mental content. There is but one mental process, embodied in the bioneuropsychodynamic relation: *In carbon molecules the heat incidental to conduction under resistance reacts upon the molecules in such manner that resistance is less for subsequent than for initial conduction; the intensification stage of this process in nerve tissue may surpass the critical, limen point, and involve the emergence of consciousness.*

There is but one mental content,—consciousness. Calling sensations, thoughts, feelings, "elements of mind," risks missing the *real* question: How comes it that consciousness, as introspectively observed, exhibits sometimes characters diagnostic for sensation (variations in quality and in intensity), sometimes those distinctive of feelings (fluctuation over the pleasantness-unpleasantness gamut), sometimes only the colorlessness of thought? The natural answer is: Differences in the aroused consciousness are referable back to differences in the evoking agencies; peculiar combinations of conscious characters are the outcome of correspondingly peculiar combinations among those agencies. Thus, consciousness *in forma* sensation differs in quality according as it is aroused by waves of auditory-nerve, optic-nerve (etc.), length; in vividness with the amplitude of the arousing waves. And the various sensation-facies assumed by the aroused consciousness are mainly outcomes of different combinations between these two independent variables.

What, now, do we *mean* by consciousness *in forma* sensation, *in forma* thought, *in forma* feeling; what are the underlying conditions entailing these introspectively observed differences in facies (of *content*); and what the respective dynamic rôles?

Consciousness *in forma* sensation: The pictorial, environment-representative ingredient in mind, exhibiting variations in quality and in intensity; exempt from laws of lapse and of fade;<sup>2</sup> office of dynamic-inseparable, introduction into composition of forces, of environmentally (spatially) interproportioned

<sup>1</sup> *Plasticity zone:* The locus of plastic neurones, embracing besides the association tracts, at least those parts of the sensory and motor areas, destruction of which obliterates memories.

<sup>2</sup> *Law of lapse:* Repetition of actions originally accompanied by thought involves progressive diminution (to disappearance) of that thought.

*Law of fade:* The rise-and-fall curve of feeling, parallels, as a dependent function, the rise-and-fall curve of the excitant intoxication; consequently, in the last analysis, the evolution-involution curve of the intoxicant organ or focus.

components ; seat, sensory area (*pars*) ; palæogenetic ; condition of arousal, critical (limen) value of relation between nerve energy and resistance in elastic molecules.

Consciousness *in forma* thought : That which lapses, the cognitive ingredient in mind ; exempt from law of fade ; office of dynamic-inseparable, reactive-dynamic effect on plastic nerve molecules, eventuating in "profiting by experience;" seat, plasticity zone ; neogenetic ; condition of arousal, critical (limen) value of relation between nerve energy and resistance, in plastic molecules.

Consciousness *in forma* feeling : The affective ingredient in emotion, exhibiting variations between opposite affective poles ; exempt from law of lapse, subject to law of fade ; office of dynamic-inseparable, intensification or minimization of reaction ; seat, special affluents of motor area ; palæogenetic or palæoneogenetic ; condition of arousal, critical (limen) value of relation between nerve energy and resistance, in intoxication-prepared elastic molecules.

*Taxonomic value of lapse.* But, it might be argued, sensations not lapsing (they are equally vivid however often experienced), are not consciousness at all ; and, *de facto* we *think* not *in* but only *of* red. Lapsing is, however, nothing inherent in consciousness *qua* consciousness, but is an incident of the type of structure in which in man consciousness (*in forma* thought) happens to be chiefly manifested. And sensations not lapsing must be assumed to take rise in structure different enough to account for the radical difference in behavior.

The alternative view offers insuperable difficulties. If sensations are in a distinct category, they either react dynamically and so back-flow into the ebbing nerve-energy current, or do not so react and back-flow. If the former, possessing in common with thought, awareness, they agree with it in all important features except lapse (otherwise explicable), and the category falls. If the latter, there is no conceivable way they can satisfy the equation of the conservation of energy, and they are left without conceivable office.

The prime taxonomic importance of lapse consists, then, in its being an index of plastic structure. Lapse appears, indeed, not for itself, but incidentally, *en route* to profiting by experience ; and thought lapsed, can, on occasion, revive as readily as it lapsed.

#### A. Pre-Compositional

*Sensations.* Sensations do not lapse by reason of biological necessity. Motor response appropriate to environmental happening can come about only as a sequel to accurate spatial orientation ; consequently, only organisms can survive in which there exists *somewhere* antecedent (in the sensori-motor prog-

ress) to the composition zone, an area in which the intensities of the incoming stimulus waves bear to one another proportions representative of the proportions obtaining among the environmental objects among which the organism has to move. This area must be antecedent to the composition area, as only so can the stimulus waves carry into the coming composition of forces a series of kinetic values so interproportioned as to be space-representative. This area will be the sensation area. For, vividness of sensation being a dependent function of intensity of stimulus, the interproportions of the vividnesses of sensations simultaneously aroused, will be (secondarily) a dependent function of the interproportions of the initiating stimuli. But this interproportion (of light, shade, color, *e.g.*) being derived from, will be representative of, existing conditions and interrelations of the environmental content of the moment. The sensation area is thus an intra-cranial camera-obscura shield-mirror, in which is perceived the direction in which the environmental Gorgon is to be struck.

The sensation area is the last stage in the sensori-motor progress, in which the intensities of the stimulus waves bear to one another proportions representative of environment; immediately succeeding this stage, these waves enter into composition with the reactive forces of the organism, forces different in every zoölogical group and individual. But the interproportion representative of environment is carried forward from the sensation into the composition stage. For, interproportion of vividness of sensation being a dependent function of interproportion of intensity of stimuli, interproportion of dynamic-inseparables, and consequently interproportions of reactive-dynamic effect and of reductions in the denominator of Ohm's formula,—all are equally dependent functions of the intensities of those stimuli. Whence, environment-proportional sensation-values, being multiplied by proportionals, remain environment-proportional.

So much for the biological necessity for constancy of relation between cortical-psychic processes and environment; what neurological conditions meet the necessity? What must be the molecule-type in the sensation-yielding neurones? One offering:

*Constant* resistance upon successive conductions.

Relatively *high* resistance.

Only with resistance constant can vividness of sensation be a dependent function of intensity of stimulus. But constant resistance upon successive conductions means a molecule yielding temporarily under the reorienting effect of the latentized nerve energy (*in forma* sensation), but *without undergoing imprintation* and reassuming its original condition upon the cessation of the reactive-dynamic action; in short, an *elastic* mole-

cule. This is no contradiction of the main thesis; carbon molecules *may be* plastic, but even in the body many are not (cartilages yielding temporarily to pressure do not yield more readily and extensively, and the cornea transmits light not better but only equally well, time after time). And carbon molecules differing in degree of plasticity, accumulation will, according to the biological necessity, take place in the direction either of plasticity or of aplasticity.

Fechner's law: If 1, 2, 3 (etc.), units of energy fall successively on 1 sq. cm. of body surface, the energy on each constituent small square of the centimeter-square (consequently, on each peripheral sense organ), is the square root of 1, 2, 3 (etc.); and the impinging energy initiates a current as the square root of the energy radiated on to body surface by the environmental source of energy, unless sense-organ activity alter proportions. But heat in the electric circuit<sup>1</sup> being as square of current strength, if the current initiated be electrical, *heat-generation in the nerve circuit is directly as energy-radiation in environment* fulfilling the biological necessity for environment-representation in the cortex, and showing how extensity in environment becomes polarized in one plane, as intensity, in the cortical-psychic zone, entailing qualitateness of consciousness (more or less) in correspondence with the biological advantage of limitation of decision, at each moment, to choice between alternatives. Comparing Fechner's with the electric-heat formula, the constant corresponds to the resistance. Two facts favor their identity,—they are multipliers of homologous quantities, the constant is invariable despite varying strengths of stimulus, resistance invariable despite varying strengths of current. Invariable for the same sense but varying from some senses to others, the constant should be a specific-energy sense coefficient, but peripheral or cortical? Sense-organ activity varying *pari passu* with stimulus, the constant not so varying, can hardly be peripheral (anyway, unless the 1:1 relation between energy-radiation in environment and heat-generation in cortex be tossed aside, the true constant is the square root of Fechner's). But, if a cortical coefficient, invariability of constant within the same, and its varying on change from some sense-realms to others, is intelligible as indicative of equivalence of dynamicity among cells of the same realm, and difference of dynamicity between cells of different realms, which

<sup>1</sup>.0009477  $C^2rt$  British thermal units,  $C$  being current (amperes);  $r$ , resistance (Ohms);  $t$ , time (seconds). Varying inversely as cube of radius of conductor, the heat generated in neurones and neuro-fibrils can be no negligible quantity. Its destiny can only be *work*, physical or chemical, probably both in different proportion in different cases and species.

accords with experience that while stimulation of one sense is never appreciated in psychic terms belonging to another sense (visual impressions never heard), vicarious interchange may take place within the same realm in hysterical reversal of the retinal color fields (explicable as intoxication-alteration of resistances, entailing cross-deflection *en route* with ultimate projection of color fields on to unhabitual cells). The constant would, then, measure the resistance of the sensation zone.

Did Fechner's logarithmic function formulate the quantitative relation between psychic and physical worlds, consciousness could not be compared with energy, no form of which interchanges with others on a logarithmic basis of equivalence. But the function seems intra-psychic; an orientation of judgment acquired through estimation of distance and speed relations of moving objects. If an animal perceive an enemy approaching from 200 meters distance, successive fractional distances traversed and distance-remainders yet to be traversed, are continually being estimated. Estimated how? Through intercomparison of sensation-vividnesses varying in dependent relation with shifting energy-impingement values incident to approach or recession in line of sight. Such intercomparison may be either of absolute sensation differences, or of the proportionate increase (or decrease) between one sensation and its predecessor. Supposing now, sensation-vividness correlated increment for increment with cortical heat, the latter equalling total energy-impingement on body surface, from a series of ascertained sensation-vividnesses we can calculate the distances whence the respective impingements were radiated<sup>1</sup> and thus test the comparative accuracy of the two modes of comparison. That scale would be best in which sensation-differences are proportional to distances traversed. But energy-impingements being as the inverse squares of distance-remainders, environmental conditions preclude *any* scale from being so proportional. Whence this most instructive case of two-story adaptation, where a series of judgment units is superimposed upon and sifts out the series of sensation units; proving that mental parallelism of environment exists not for sake of such parallelism, but because in general parallelism corresponds to maximum adaptation.

The table shows that at 200—199, for both series, the sensation-difference is 0.01, the "just noticeable difference" for vision; whence, 200 marks the diverging point of the two series.

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<sup>1</sup>If with 200 meters distance, impingement ( $i$ ) = 1, for any point,  $p$ , distant less than 200,  $i = \left(\frac{200}{p}\right)^2$ , and  $p = \frac{200}{\sqrt{i}}$

*Comparison of sensation-differences and distances traversed.*

BOTH SERIES		COMPARISON BY EQUAL SENSATION-INCREMENTS OF 0.01			COMPARISON BY LOGARITHMIC INTERVALS		
Number of term	Distances traversed should be	Distance- remainders ( $p$ )	Distances traversed ( $200-p$ )	Separate Comparisons per meter	Distance- remainders ( $p$ )	Distances traversed ( $200-p$ )	Separate comparisons per meter
4I	40	169.03	30.97	—	163.92	36.08	—
8I	80	149.07	50.93	2	134.35	65.65	—
12I	120	134.84	65.16	2	110.11	89.89	—
16I	160	124.04	75.96	4	90.246	109.754	2
20I	200	115.47	84.53	5	73.965	126.035	—
24I		108.46	91.54	6	60.621	139.379	3
28I		102.6	97.4	—	49.685	150.315	4
32I		97.59	102.41	8	40.722	159.278	—
36I		93.25	106.75	9	33.375	166.625	6
40I		89.444	110.556	10	27.354	172.646	—
44I		86.068	113.932	12	22.42	177.58	8
48I		83.046	116.954	13	18.375	181.625	10
52I		80.323	119.677	15	15.06	184.94	12
56I		77.85	122.15	16	12.343	187.657	15
60I		75.593	124.407	18	10.116	189.884	18
100I		60.303	139.697	26			
500I		28.006	171.994	125			
1000I		20.	180.	625			
4000I		10.	190.	3000			

Clearly only organisms can survive in which, where complicated distance judgments (animal, enemy, or both, moving) are in question, sensations do *not* enter for their face values into, but find *some* reactive coefficient of correction in, the composition of forces. For, the sensation-increment does not even roughly approximate distance traveled; the sensation difference per meter differs widely in different portions of the line of approach (200—199, 0.01, 20—19, 10.8); and the number of separate comparisons is prohibitory. Further, as no animal could continually bear in mind the initial 200—199 increment as a referendum, intercomparison must come to be with *some* later term. But the later term, comparison with which involves greatest accuracy, is the next preceding. Such comparison



cannot, however, be on the increment basis, the distance-value of the increment varying too widely in different portions of the line of approach (200—199, 1 meter for 0.01; 20—19, only 0.001 for 0.01). Consequently, intercomparison must tend toward proportionality; toward the logarithmic. But such continual referendum to the next preceding sensation-value as a basis applies to logarithmic comparison exactly the corrective required to make it closely approximate to distance traveled, as that referendum makes that term the initial member of a new series with corrected base. The logarithmic series is seen to cover the whole line of approach with a series of sensation-differences not accurately proportional to distance traveled, but near enough for practical purposes; the sensation-differences vary far less widely in different portions of that line; and the number of separate comparisons is practicable. But judgment being in animals more exercised on distance and speed relations of moving objects (enemies, prey) than on all else together, all discrimination of sensation will come to be similarly oriented; toward logarithmic comparison. But such discrimination will not continually be attained by re-decision, but consciousness will lapse to the optimum limen, the "just noticeable difference," the *judgment* unit, not the sensation unit.

Meeting this biological necessity are composite-photograph imprints in the plasticity zone (all the "learning" machinery) ensuing upon the innumerable trial-and-error experiences; (and, *de facto*, the young often exhibit imperfection in distance judgment) reinforced by elimination of the unready and inexact, and eventuating in a race in which judgment approximates the logarithmic type.

But if this be accepted as good and sufficient explanation of Fechner's law, then, successful explanation of that law hitherto mysterious, reflects retrospective lustre on the hypotheses which enabled such explanation,—that nerve energy is electricity, and that sensation is correlated increment for increment with cortical heat.

What does logarithmic proportionality mean dynamically; what neuromolecular conditions operate to magnify the small sensation-increments into the larger hiatuses of the J. N. D.? Unless I give up all won so far, or assume a psychic-cortical correlation for the plasticity zone different from that assumed for the sensation area, I must reason: Discontinuity in sensation-discrimination means discontinuity in plasticity-zone heat-generation; but with  $C^2$  and  $r$  increasing subcontinuously, the heat increases by small increments (retaining visual discrimination as the example,  $a$ , 1.001 $a$ , 1.002 $a$ , . . . 1.009 $a$ ); and while the relation  $r$  not  $> \frac{1}{C^2}$  must *somehow* obtain in order that

neurone A shall yield sensation  $a$  upon impingement  $a$ , nevertheless  $r$  and  $C$  being independent variables, appeal must lie to discontinuity-elements in the substrate.

*Hypothesis.* Sensation-discriminating neurones (or neurone-grouplets) of the plasticity zone constitute a step-by-step graded series, A, B, C, . . . . Z, each neurone of which can rob (via collateral afflux consequent upon preponderant resistance-reduction) the territories of the other neurones according to circumstances and within narrow limits; for current values making  $C^2r =$  successively to  $a$ ,  $1.001a$ ,  $1.002a$ , . . .  $1.009a$ , neurone A holds its own as against B, but the value  $a$  ( $1+.01$ ) reached, B robs A, but holds its own as against C so long as the value  $a$  ( $1+.01$ )<sup>2</sup> is not reached, at which point C becomes able to rob B (also all other neurones). Motor connections of constituent neurones are peremptory in proportion to the robbing power of such neurones. Each neurone consists of molecules specialized (via optimum lapse and Preponderant Survival) in such manner that  $r$  not  $> \frac{1}{C^2}$ , but  $r$  and  $C$  being

independent variables, that limitation of value cannot come about through purely physical causes, but for neurone A (specialized for sensation  $a$ ), supplementary heat-values  $1.001a$ ,  $1.002a$ , . . .  $1.009a$ , *some chemical* alteration (presumably slight isomeric) must occur involving absorption in intra-molecular work.

This explains the disproportionate "attention" and reaction to strong stimuli. Also, it accords with the biological advantage of mental shock in arousing attention (meaning dynamically, promptness in robbing other previously active tracts, thereby turning nerve energy and consciousness in the newly needed direction quickly).

Inheritability of "learning" structure. Sensation-discrimination thus seems a matter of trial-and-error ("learning") adaptation, reinforced by "selection" among carbon molecules differing in initial resistance and capacity for ultimate modification; in plasticity, that is. Romanes believed the question of inheritability of acquired characters would be settled in the psychic realm, if anywhere. But there seems no necessity for assuming such inheritability in that realm; and the Baldwin-Osborne-Morgan "factor," the subtlest device for getting something out of nothing in matters psychic I have ever met, is superfluous. The "factor" is (1) in each successive generation the young learn anew a survival-requisite special artifice the learning of which saved the parents to the breeding period; until such time as (2) variations in the same direction appear in the germ. But *can function outrun structure?* Bodily

structure, yes; plastic structure, no. "Learning" *does not come from nothing*; learning capacity is imprintation capacity which is a dependent function of the plasticity interrelation, the relation between initial resistance and ultimate modifiability. But equally with other brain structure, plastic molecules present in the parents can, on *any* theory of heredity, reappear in ("be transmitted to") and vary in the offspring which, as compared with the parents as regards degree of perfection of the plasticity interrelation, may be on a par with, inferior to, or superior to them. Pending contrary proof, however, these differences are variations strictly comparable with other variations ("spontaneous," *de facto*, and from unknown causes). But the "acquired" imprintation-improvements of the parents cannot, so it is said, be "transmitted." Waiving discussion of what I know naught about, here at least it is not necessary that they should be; for "transmission" of learning-ready machinery entails learning-readiness of offspring on occasion (the "variations in the same direction" are *already* "in the germ"). Thus incidentally and in a manner the reverse of the Baldwin hypothesis, the young of ready-learners of the artifice, re-learn it, thereby surviving in largest percentage to the breeding period and leaving largest percentage of offspring. And obviously the limit of the process is a readiest-learning race, eventuating in one which is *pre*-ready, not needing imprintation-improvement of the plasticity interrelation, one which is able to execute appropriate motor response the first time occasion demands. Several degrees in the approximation-series can be seen in young animals of different species.

Consciousness. The logarithmic function relegated to the distal side of the sensation-thought boundary, no objection remains to translating the "rigid correspondence" of page 63, into: Correlation increment for increment; and consciousness and the cortical heat-like energy fall, dynamically, within the limits of one kinetic species, the name of which may as well be consciousness as anything else. And Penultimate Philosophy will say: Consciousness is the dynamic factor (the cognitive integral) in "profiting by experience." The consciousness wave-series probably adjoins (or more or less overlaps) the lowest of the heat series, extending thence indefinitely downwards. This position is, dynamically, most striking as in keeping with the character of consciousness as a *compromise* energy; one (perhaps the only one) into which can be directly and readily compositioned all the diverse energy-types impinging upon organisms,—the molar-motion type (all mechanical impacts including olfactory); aerial sound pulses; the several etheric-vibration series. Conveniently analyzable as dynamic- and psychic-inseparable, it may well be that "in-

separable" should be *identical*. For, there being no antecedent indication as to what properties waves referable to hitherto unknown portions of the spectrum should have, awareness may come to be accepted as *de facto* inherent in these particular waves, as is expansion-induction in those of the termic series, and silver precipitation in the ultra-violet, no one property being any *more* unintelligible than another.

### B. *Compositional*

Recapitulating, every moment innumerable waves initiated by sensory stimulation are surging up through tier after tier of afferent neurones. At every successive millimeter of the upward progress, the waves are divisible into two classes,—waves for which antecedently permeable routes exist in the transverse sensori-motor connections at that level, and waves for which the antecedently permeable route is upward. The waves making up the progressively diminishing residual of the second class come ultimately to be deflected into the sensation area, where increased resistance involves friction with consequent latentization of nerve energy beyond the limen point, whence emergence of sensation, followed by the passing on of the waves, space-representatively proportioned.

Like other nerve action, plasticity-zone action is merely repetition of what it has been in the past, with two differences,—differences the outcome of past imprints, and differences due to variations in "functional condition" (intoxication, including fatigue). And it is just because such differences cannot be excluded, that the sketch to be given will depart from our actual experience of mental action. But now the constants in nerve action are under analysis. Plasticity-zone action falls naturally under: Route, and the three-faced indecomposable fundamental fusion-composition-reorientation process, the distinctive feature of such action.

*Route.* This is strictly a dependent function of the several resistances, and (variations in functional conditions apart) these are strictly such function of the imprintation conditions. Thus is explained how the "experiences" of the individual, though past, can still enter, as a present factor in reactions. For, route incidentally determines which among the myriad host of cortical cells shall be impinged upon and stimulated. Route thus determines *kind* of nerve energy liberated (so to speak). But imprintation conditions have nothing to do with the *amount* of nerve energy liberated, that amount being exclusively an outcome of accumulations via Preponderant Survival, and in present reactions varies *pari passu* with different intensities of the same stimulus.

*Fusion.* Fusion-focus:—Sufficient gradient accumulated,

the sensation waves penetrate the plasticity zone, everywhere along the antecedently permeable routes. Penetrate how far? Till they can penetrate no farther; till they impinge in the abutment area of a fusion focus, a rheostatic *cul-de-sac*, exit from which is impossible for the waves *as such*, and possible only for their fusion wave. How could such a "focus" come about? Take the most difficult case possible (rather impossible). Suppose a system of neurones, all unimprinted and all equally plastic, every neurone forming terminal arborizations round the cell of every other neurone; neurone A arborizing round B, C, D, etc.; neurone B round A, C, D, etc.; neurone C round A, B, D, etc. Then A arborizes round B and B arborizes round A, A round C and C round A, A round D and D round A, B round C and C round B, etc. In such a system, impinging energies will start waves radiating in all directions; stimulation of A, *e.g.*, will be followed by radiations out to all its terminal arborizations. But stimulation of the circum-arborized neurones (B, C, D, etc.), will start secondary waves radiating out from each such neurone to all its arborizations, thereby stimulating all those circum-arborized neurones to radiate tertiary waves,—till waves of higher order fail to evoke further energy liberation. But all those waves imprint; and some environmental happenings recurring more frequently than others, certain stimulus waves recur in particular combinations, correspondingly more frequently; whence, inevitable inequality of imprintation conditions. For, in the neurone system supposed, with incoming waves corresponding to the ingredient sensations, *a, b, c*, of a concept, *abc*, impinging on neurones A, B, C, the routes radiating out from all the neurones of the system will fall as regards the type of the resulting imprintation, into three classes,—*intra-focal* (A-B, B-A, A-C, C-A, A-D, D-A, B-C, C-B, etc.); *exo-focal* (A-E, B-E, etc.); and *extra focal* (E-F, F-E, E-G, etc.). And the imprintation types will be:

## ROUTE A-B

1. Primary waves generated in cell A under stimulation of incoming sensation waves (of A type).
  2. Secondary waves generated in cell A under stimulation of B-A primary waves.
  3. Tertiary waves generated in cell A under stimulation of B-A secondary waves.
- Etc.

## ROUTE B-A

- Primary waves generated in cell B under incoming sensation waves (of B type).
- Secondary waves generated in cell B under stimulation of A-B primary waves.
- Tertiary waves generated in cell B under stimulation of A-B secondary waves.
- Etc.

And what takes place along routes A-B and B-A takes place equally along other intra-focal routes. Very different is the imprintation along the exo-focal, and still more along the extra-focal routes.

#### ROUTE A-E

1. Primary waves generated in cell A under stimulation of incoming sensation waves.

No secondary waves.

Tertiary waves generated in cell A under stimulation of E-A secondary waves.

No quaternary waves.

#### ROUTE E-A

No primary waves.

Secondary waves generated in cell E under stimulation of A-E primary waves.

No tertiary waves.

Quaternary waves generated in cell E under stimulation of A-E tertiary waves.

Consequently, the routes interconnecting A, B, C, and D, being each time more frequently and more intensely imprinted, will with every new advent of the particular stimulus-combination, tend more and more to routes of lessened resistance, as compared with the exo-focal routes; whence, diffusion will ever be more limited to the forming focus, thereby accentuating the difference between the intra- and exo-focal resistances; leading to stricter limitation to the focus, etc. The depth of such imprintation and super-imprinting will depend both upon frequency of recurrence and degree of plasticity; and as the process in question involves the only element of survival value in plasticity-zone action, variations in plasticity will accumulate via Preponderant Survival.

A fusion focus is a physiological rather than an anatomical entity, and denotes merely a number of neurones which in the presence of certain particular sensation waves, act together, but any or all of which neurones may, in presence of other sensation waves, act in connection with any extra-focal neurones to form other similar foci. Consequently, the form and size of such foci may be anything; the focus may consist of closely contiguous neurones, or of neurones separated by the length and breadth of the plasticity zone.

Fusion :—The intra-focal routes are thus imprinted by primary waves, and super-imprinted by waves of higher order. The latter, generated in the same cells under stimulation of different character, may be assumed (pending contrary proof or emergence of discrepancy) to differ in *some* respect from the

corresponding primary waves.<sup>1</sup> But, if they differ at all, fusion seems certain. For, the plastic carbon molecules of route A-B, would, if imprinted exclusively and repeatedly by primary A waves, attain to an orbit form vibrating in unison with those waves. The subsequent action of a different wave type upon an orbit form so modified would tend to modify it in another direction, that leading to an orbit form vibrating in unison with those second waves. As, however, the molecules are not subjected exclusively and repeatedly to the action of the second waves, but are subjected alternatively and repeatedly to the action of the first and second waves, the only possible outcome, these waves being different, is the emergence of an orbit form vibrating in closest harmony with both the remoulding waves, one whose proper note (so to speak) is an harmonic of both their vibration rates.

Waves vibrating in unison with an orbit form will be transmitted without change. But where their vibration rate differs from that proper to the orbit form, more or less interference with consequent absorption will ensue. With absorption, however, heat will emerge and modify the orbit form toward unison (or closest harmony) of vibration rates. Except for unison waves, then, every transmission will be the outcome of reciprocal readjustment (of a vibrational composition, so to speak), orbit form modifying wave, wave modifying orbit form; the amount of change undergone by orbit form and wave, respectively, differing in different cases. But with every additional imprintation and super-imprintation, the proportion which a single new imprintation bears to the sum total of all past imprintations and super-imprintations is continually diminuendo. Consequently, the effect of such new imprintation upon an orbit form once established is likewise continually diminuendo; or the effect of orbit form on wave is continually crescendo. Whence, waves impinging on orbit forms perfectly attuned, either, if too remote in vibration rate (too dissonant) are not transmitted at all, or, if harmonically reducible, undergo absorption sufficient to admit of their vibration in harmony with the orbit form become relatively inelastic (or elastic within comparatively narrow limits) through repeated modification in one direction.

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<sup>1</sup>Parenthetically, the orbit form of route A-B, being imprinted by the more intense primary waves, and super-imprinted only by the less intense waves of higher order, will, though modified to an harmonic ratio of B, remain fundamentally A in type; meaning that its vibration rate will approximate to unison with that of A type, but only to harmonic ratio to that of B type. Conversely, the orbit form of route B-A, will be fundamentally B in type, and only harmonic to A. And what takes place along routes A-B, B-A, takes place equally along other intra-focal routes.

But potential raised in the abutment area, discharge must occur somewhere; either the immediate final discharge from the focus, or a mediate discharge on to other intra-focal neurones. On the second alternative (as the more difficult case), discharge will be on to more or fewer neurones (discharge on to the same number only postpones the question). If it be said that discharge from the abutment area is primarily on to more neurones, and that reconcentration (discharge on to fewer neurones) first begins later, it comes to the same thing, the contention merely changing the question to this: Is the abutment area the place where for these particular waves, the principle of the increasing complication of paths reaches its limit, or does that principle first reach its limit in some post-abutment (but still intra-focal) area? The abutment area denoting the last point to which the waves can without change penetrate the plasticity zone, the question lacks standing ground unless it mean contention that harmonic reduction confers further penetrating power, a contention unimportant concerning which no presumption arises, pro or con. *The question lies between :*

*Hypothesis.* Discharge from the focus occurs with ever increasing diffusion, no reconcentration on to fewer neurones taking place.

*Hypothesis.* Discharge from the focus occurs via reconcentration on to fewer neurones.

On the first alternative, energy existent in the abutment area would be dissipated correspondingly to the diffusion; whence, its psychic-inseparable would dwindle in vividness, all the time persisting *in forma* sensation. But we observe the energy concentrate to reaction, and the sensations integrate to a concept; whence a presumption in favor of the second alternative, which, besides, corresponds with what obtains for the plasticity zone as a whole, where discharge via fewer neurones is demonstrable anatomically in the diminishing number as we pass down the motor side, and marked psychically by concentration of "deliberation" into "will" and "effort." Since, then, the law for the part cannot be presumed different from that for the whole, discharge via fewer neurones is legitimate hypothesis. But such discharge means simultaneous impinging of two (or more) different sensation waves, reduced to harmonic ratios, upon the same neurone. As, however, its orbit form cannot, at one and the same time, vibrate in unison with each wave separately, the only possibility will be the assumption by it of a vibration rate to which the rates of both (or all) the waves can be assimilated; a rate which includes all rates, a common (and inferentially the least common) multiple of the



separate rates,—which means vibrational composition to a fusion wave.

*Composition of forces.* This is involved in (is only another side of) fusion. Unless the conservation of energy be repudiated, the amplitude of the fusion wave must be assumed to represent the algebraic sum of the intensities of the components; and that of the super-fusion wave to correspond to such sum of all the waves undergoing super-fusion.

In reaction to these incoming sensation waves, and more especially to their fusion (super-fusion, etc.) wave, the plasticity-zone cells liberate a vast amount of energy, an amount the liberation of which in the past sufficed, *de facto*, to ensure motor response adequate to the exigency announced or presaged by the stimulus. But (variations in "functional condition" always apart) being compounded and super-compounded from equals, the final resultant will equal the predecessor resultant, whence exit having been possible for it, will equally be possible for the present resultant along the route imprinted by its predecessor in its exit. Consequently, discharge will ensue on to those motor mechanisms on to which that predecessor discharged, and discharge on to which sufficed to preserve the organism in former similar emergency, or to preserve its ancestors to the breeding period.

In different cases, the energies contributed by the organism bear very different proportions to the incoming energies; the former may predominate or be insignificant. The *biological* resultant (that of the composition of *all* the forces) will, then, be incalculable, not because it departs (as far, at least, as there is any evidence) from the path of mechanical exactitude, but incalculable by reason of our ignorance of the values to be assigned to the intra-organismal forces in any given case. Especially will these forces differ widely in amount, since each organism reacts not to the immediate happening announced by the stimulus, but to its coming sequels; to sequels which are members of œcological series which though having the initial term in common, nevertheless differ for every species or other zoölogical group.

*Superfusion, Supercomposition.* Fusion-composition taken place, the fusion wave following the exit route imprinted by its predecessor will undergo either final discharge from the plasticity zone, or reach some limit within that zone progress beyond which is impossible for it as such wave, another abutment area round which another (superfusion) focus will build up. The latter (more frequent) case underlies all those congruous serializations of associations constituting "trains of thought." In the new focus, fusion-composition is repeated,—and so on, till final discharge on to the motor mechanisms.

*Reorientation.* Is incidental to fusion-composition, the direction of exit of the fusion wave being given between its vibration rate and the imprintation conditions along the exofocal routes. The essence, dynamically, of reorientation, lies in redistributions in the kinetic field, the outcome of which is discharge on to motor mechanisms whose action saved in similar emergency. Reorientation and reaction are thus merely consecutive phases in one process, of which psychogeny is but another aspect.

But why do mechanisms already acting give over their activity upon the advent of stimuli arousing activity in other mechanisms, "attention" coincidentally moving over? No organism can at the same moment "compose" (attend to, deliberate and decide upon) all the inthronging stimuli annunciative of happenings at that moment (*de facto* attention to plurality of subjects is difficultly acquired and is unknown among animals). Consequently, those organisms only can oppose to happenings appropriate response, which have accumulated selective receiving capacity. Through biological necessity and Preponderant Survival, such capacity must come to be oriented parallel with the œcological-importance scale of happenings. What neurological condition meets this necessity? Graduation of the antecedent-permeability scale parallel with the œcological-importance scale. Being variable, selective receiving capacity cannot lie in the sensation area (the locus of constancy of relations), but must be a plasticity-zone or feeling-tract matter. In the plasticity zone, it is the outcome of the fundamental dynamic constitution of the nervous system and of the imprintations (except to the not small extent to which intoxication conditions affect zone action). Stimuli entering the zone in order of œcological importance, if stimulus *a* enter neurone A, it will (supposing the stimulus continue acting) continue to flow along such tract as long as resistance along that tract remains less than along tracts entered by later stimuli (*b, c, d, e*). For, with resistance along A relatively minimal (otherwise *a* would not have entered it in preference to other tracts) and further lessened by the conditions involved in functioning (resistance-reduction consequent upon heat of passage of current), energy will inflow on to tract A from all collateral points. But with the advent of stimulus *f* into tract F in which *f* encounters less resistance than does *a* in tract A, direction of energy flow will become reversed, and F will rob A. Energy will, however, flow in from points at which potential previously stood highest, from tract just active, where, consequently, consciousness was most vivid. But with such drafting off from those tracts, consciousness there will first pale and then vanish, while it will as steadily rise to a bright glow (so to speak) in

the newly active area. Whence, we shall have just that shifting over from consciousness of the previous to that of the present subject, which we introspectively observe.

In the feeling tracts, pre-antecedent permeability is an outcome of graduation of intoxication conditions parallel with the œcological importance scale. Consequently, the supplanting of a former stimulus, by a subsequent one, is evidence of intoxication preparation (resistance-reduction).

### C. *Concurrent-Compositional*

Some think mind originated in "some form of sentience," a vague phrase for: Sensation plus feeling. With these ingredients, simply environed organisms would be in position to oppose to happenings appropriate response, since they would possess a space-orienting and a reaction-regulating (intensifying or minimizing) factor. Before the intrusion of the thought-wedge, reaction-sequences, *sine qua non* for existence, might come to be organized through adjustment of activity of the second factor, via accumulation of optimum gradations in intoxication conditions (the first factor, environmentally determined, is for every organism a fixed quantity and the point of departure). Neurologically, this means a vast number of neurones organized into a connected whole, with the resistances of the constituent neurones just such as to ensure optimum serial motor response. What would be the psychic condition along such tracts? Sensations and feelings being non-lapsing conscious states, the tracts should be conscious tracts. The gradual intrusion of the thought wedge will introduce comparatively little (though as we ascend the zoölogical scale, ever progressively more) modification; and that in the way of inhibitive regulation or control. For, the biological necessity remaining the same, unless motivation of the established reaction-sequence should come to pass over to the thought wedge, it will remain where originally organized. But the offices of feeling and of thought (rather of their dynamic-inseparables) differ radically. That of feeling is ensuring of certainty of performance of serially connected, and promptness of execution of suddenly necessary, reactions, thus contributing to survival in face of emergency. But the survival value of thought lies in the fore-warning accruing in connection with it, so long in advance of emergency, that there will be none. If the senses be arranged in order of the warning afforded of happenings, touch and taste afford warning only upon contact; smell and hearing cover a range of at most a few miles; sight, somewhat or much more; but the warning in connection with thought is without assignable limit. Which means this, and *no more*,—that the conditions involving emergence of thought are equally those involving

"profiting by experience," involving boundless possibilities of resurrecting experiences (and experience-fragments in new juxtapositions and combinations), to extemporize a color-scale (so to speak) against which to match any incoming stimulus-complex, to the end that its ground tint being ascertained, its coming sequels may be "inferred" from the *de facto* sequels of its ground-tint match, long in advance of their advent. Thought is thus *the* prophetic sense.

Analysis thus reveals between sensation and motor function *two* bridges, a sensation-feeling-motor and a sensation-thought-motor bridge, differing in antiquity and in office. Otherwise put, besides the two recognized types of nerve action, reflex and conscious, a third type exists, reflex-though-conscious or pleasantness-unpleasantness action, which is in no sense intermediate between the other two, being altogether differently (namely, intoxication) motivated.

Feelings not lapsing, the underlying molecule type must be assumed elastic. Feelings being a dependent function of intoxication, the predisposing dynamic-inseparable must be assumed to originate through intoxication-induced metabolic processes. But to this *basis* dynamic-inseparable comes to be super-added, reinforcing dynamic-inseparable arising through latentization of nerve energy radiated in from the sensation area, entailing intensification beyond the limen point and emergence of feeling. Were feelings wholly the outcome of such latentization, however, they would be dependent functions of sensations and consequently (composition not occurring in elastic-molecule tracts) dependent functions of intensity of stimulus.

It now becomes intelligible why feeling and thought are independent variables, some exhibiting predominance of one ingredient, some of the other; also why in the same individual, intense thought and intense feeling alternate, rarely coincide. The intoxication substrate also explains the feeling variations classified on pp. 81-83. In salmon, *e. g.*, paralleling seasonal development of the reproductive organs, inshore movement begins, the initial term in a months'-long concatenated reaction-sequence, each member in which involves progress of the organism to a point where it will encounter the next supersensory stimulus. What share has intoxication? Given a sequence too long-lasting and complicated for successful execution via reflex action, the only way all available energy can remain concentrated for months within narrow channels, without fatigue, is through an elastic-molecule system maintained in constant reorientation by continuous intoxication-induced generation of dynamic-inseparable, whereby one series of tracts becomes *temporarily* (cyclically, seasonally) reflex, in constant

pre-readiness for response to those stimuli which initiated in the parents motor responses, whose eventual outcome was successful spawning.

The only alternative is that the salmon "knows." What does this *mean*; to what commit one? That the salmon *thinks*: "perceiving my ovaries swell, I know my time approaches, I must turn inshore, enter the river, ascend to those gravelly stretches near the headwaters, there build my nest and spawn my as yet hardly begun eggs." Absurd! More important, *why* absurd; only by analyzing out justification for contemptuous repudiation can one advance toward precision of thought. Ascription to salmon of such thoughts is unwarranted because (1) only in the Columbases of the human does thought attain to fore-triangulation of a mental chart whereby migration *per saltum* across a hiatus can be steered. Because (2) such thoughts involve appreciation of interrelation of organism and environment amounting to self-consciousness which is an outcome of introspective observation of the sequential relation between sensations and mental operations, and between those operations and motor (glandular, etc.) response,— which observation sums to recognition that, psychically, body surface represents the locus of all points in the universe from which originate initiators of psychic ingredients (sensations) which form the first members of series of which feelings and thoughts are subsequent members; and that body surface represents, coincidentally, the locus of the limit points to which can be followed out the sequential relation of feelings and thoughts to motor response. More briefly, body surface represents the limit points of sensation and "will," equally whether the universe be mind-constructed or only mind-reflected. But then self-consciousness cannot antedate phylogenetically the rise of introspection, the only distinctively human psychic trait.<sup>1</sup> Be-

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<sup>1</sup>Psychologists make far too little of introspection, James merely saying it is "mysterious." Introspection offers no special difficulty. Thought emerges whenever the relation between nerve energy and resistance comes to exceed the critical limen point, *irrespective of the source* of the instreaming energy. For every superfusion focus, that source is some other part of the plasticity zone. But the superfusion consciousness comes, *de facto*, to include appreciation of the sources and relations of the instreaming energies; to include, *as superfusion content*, the consciousnesses which those energies simultaneously arouse or immediately precedingly aroused. The consciousness of simultaneous or immediately precedent consciousness is thus inherent in superfusion; every superfusion focus is potentially introspective. But introspection involves two complementary conditions, the "power of volition," and *sufficient continuance* of the observed and observing consciousnesses. Neglecting the first condition as *flatus vocis*, so long as environmental (especially escape and food) needs press so continuously and insistently as to necessitate biologically (and conse-

cause (3) "attention" could not be maintained for months unwaveringly concentrated upon efficient performance of the details of the migration. And because (4) did the enormous amount of energy expended pass through the plasticity zone, imprintation on a phenomenal scale must occur. But in species migrating year after year, following cessation of the breeding intoxication, the individuals revert to seek-food reactions, contra-indicating phenomenal imprintation. In such species, too, and also where all the parents die before hatching, the young perform, untaught, the first migration as well as the old; whence here, profiting by experience (plasticity-zone action) does not enter. From the foregoing, then, migration cannot be thought-motivated.<sup>1</sup>

*Allocation.* Not lapsing, feelings cannot take rise in thought tracts; independent of intensity of stimulus, they cannot belong in the sensation area. Were feelings in *any* case "in the sensation," that case would be the preputial dermal sensation; yet even here, pleasure is not "in" the *sensation*, as the latter is *always* present, pleasure on preputial retraction present only sometimes (erotism) and *post-ejaculationem* pain is "in the sensation."

Whence, inferentially neither is in it, but sensations fall, as regards pleasantness-unpleasantness relations, into two groups, —sensations tributary, in general, to pleasantness tracts, and sensations tributary, in general, to unpleasantness tracts. And the abrupt shift-over *post-ejaculationem* from pleasurable to painful means de-intoxication alteration of resistances whereby sensation waves previously tributary to pleasantness tracts become tributary to unpleasantness tracts. The sensation is tributary during erotism to pleasantness tracts because such tracts are those involved in innervating evacuation (observable correlation between pleasure-increments and rhythmical pre-ejaculatory pulsations). Whence, pleasure fluctuates synchronously with the *motor* side.

Similarly, pain (a sensation, being equally vivid, however often experienced) is, in general, tributary to unpleasantness tracts, not because pain *qua* pain is necessarily unpleasant, but

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quently through Preponderant Survival to entail) the preter-lability of orientation finding psychic expression in ultra-distractibility, such sufficient continuance remains impossible. But when plasticity-zone development attains a stage admitting of fore-calculation covering a range far enough in advance of happenings to involve *leisure* (pastoral, agricultural stages), integration of mind has reached the introspection-possible stage.

<sup>1</sup>When my "Habits of Fishes" (*Amer. Journ. Psychol.*, XIII, 1902, pp. 408-25) was written, I had not recognized the existence and importance of the intoxication factor. That factor complements and completes the explanation there given.

because being the specialized danger-signal sensation, it must, in accord with biological necessity, be tributary to the escape (drawback, run-away, etc.) tracts. Pain is not always unpleasant. In slight dental periostitis, while never losing the pain quality, it is associated with pleasurable (lustful) tingle; an exaggeration, through inflammatory over-sensitiveness, of the frequent association of biting with lust. In severe grades of the periostitis, both this tingle and pain-unpleasantness are commingled in different degrees.

The close connection between feelings and the efferent side appears from the striking prominence of motor elements in those complex pleasantness-unpleasantness states termed "emotion," and from the relief of pent-up emotion through its motor expression; from the culmination of sexual pleasure coincidentally with a motor act (evacuation); and from coincidence of the pleasantness gamut with high efficiency, and of the unpleasantness gamut with inefficiency (fatigue, inflammation, etc.) of the motor apparatus.<sup>1</sup> Such close connection suggests allocation to the "motor area or special affluents of it," which affluents are the "feeling bridge." Like the fusion focus, this bridge is (at present, at least) rather a physiological than an anatomical entity; but unless the preceding analysis is to go for naught, to this bridge corresponds the bulk of the cortical sensori-motor connections in vertebrates whose hemispheres are limited to the oldest basal convolutions (hippocampus, etc.). If, then, feelings be regarded as consciousness-facies taking rise in neurone-systems in close connection with the *efferent* (particularly the ad-muscular) apparatus, and as facies whose predisposing condition of arousal is intoxication and whose office is intensification or minimization of motor (or other) response, we come near a theory of feeling.<sup>2</sup>

Dynamic interrelation of feeling and thought tracts. Can "feeling cause thoughts," in the unphilosophic argot of the day; meaning, can energy which in transit through feeling

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<sup>1</sup>Likewise other bodily organs; most striking with the musculature, because its innervation is associated with consciousness.

<sup>2</sup>Feelings *may* be naught else than consciousness arising in the motor area itself, consciousness of height of potential (state of efficiency of) that area. This position (distal, in the sensori-motor progress, to "attention") would accord with the elusiveness of feeling upon introspection. Feelings could then be thought of (enter the composition of forces) only as modification of thought-*content*, the outcome of repeated experiences of the relative ease or difficulty of inhibiting their motor expression; and, *de facto*, paralleling the biological necessity, we are able to gauge the character and force of the coming movement in advance. But, tentatively, it suffices if the connection of feeling with the *efferent* side be accepted.

tracts has aroused feeling, subsequently pass into the plasticity zone and arouse thoughts? Introspection warrants an affirmative; repeatedly deliberation is influenced and decision warped by feeling components. More convincing, feelings are remembered, and memory is explicable only as an imprintation phenomenon. Feelings are remembered, then, in terms of their association values.

Can energy coursing in the thought watershed overpass the divide into the feeling watershed ('thoughts cause feelings')? This question can first be answered after introspective restudies with due consideration of the problems here raised, particularly that of the paramount importance of intoxication processes. For myself, the more I have come to realize the wide range of that influence, the more I trace in cases, in which formerly I should have replied to the above question unhesitatingly in the affirmative, intoxication changes underlying and accounting for the newly appeared deflection of energy flow. Therefore, I suspect the future will say: Failing intoxication-induced lowering of resistance, the feeling tracts as a class have a relative higher resistance than the thought tracts as a class; whence, to the extent that intoxication does not enter as a resistance-reducing factor, energy entrant from the sensation area will trend predominantly into the thought tracts, and to the extent to which intoxication does so enter, energy so entrant will trend predominantly into the feeling tracts. And the relative extent to which that energy passes into the two classes of tracts has been determined through accumulation via Preponderant Survival,—in the former case of increments in the direction of optimum plasticity, in the latter of increments in the direction of optimum intoxication conditions.

### III. INFRA-LIMINAL NEURONES<sup>1</sup>

The infra-liminal ad-cortical and ab-cortical neurones must consist of molecules offering:

*Constant* resistance.

Relatively low resistance.

Resistance must be constant, otherwise sensation could not be a rigid dependent function of intensity of stimulus (and space-representation would be impossible); and, on the downward side, co-ordination would be impossible. Resistance must be low, at least to the extent of always being infra-liminal.

There is no reason to think this molecule type the outcome of lapsed consciousness; rather it is apparently phylogenetically older than the molecule type of the plasticity zone.

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<sup>1</sup>*Infra-liminal: Permanently subliminal.*